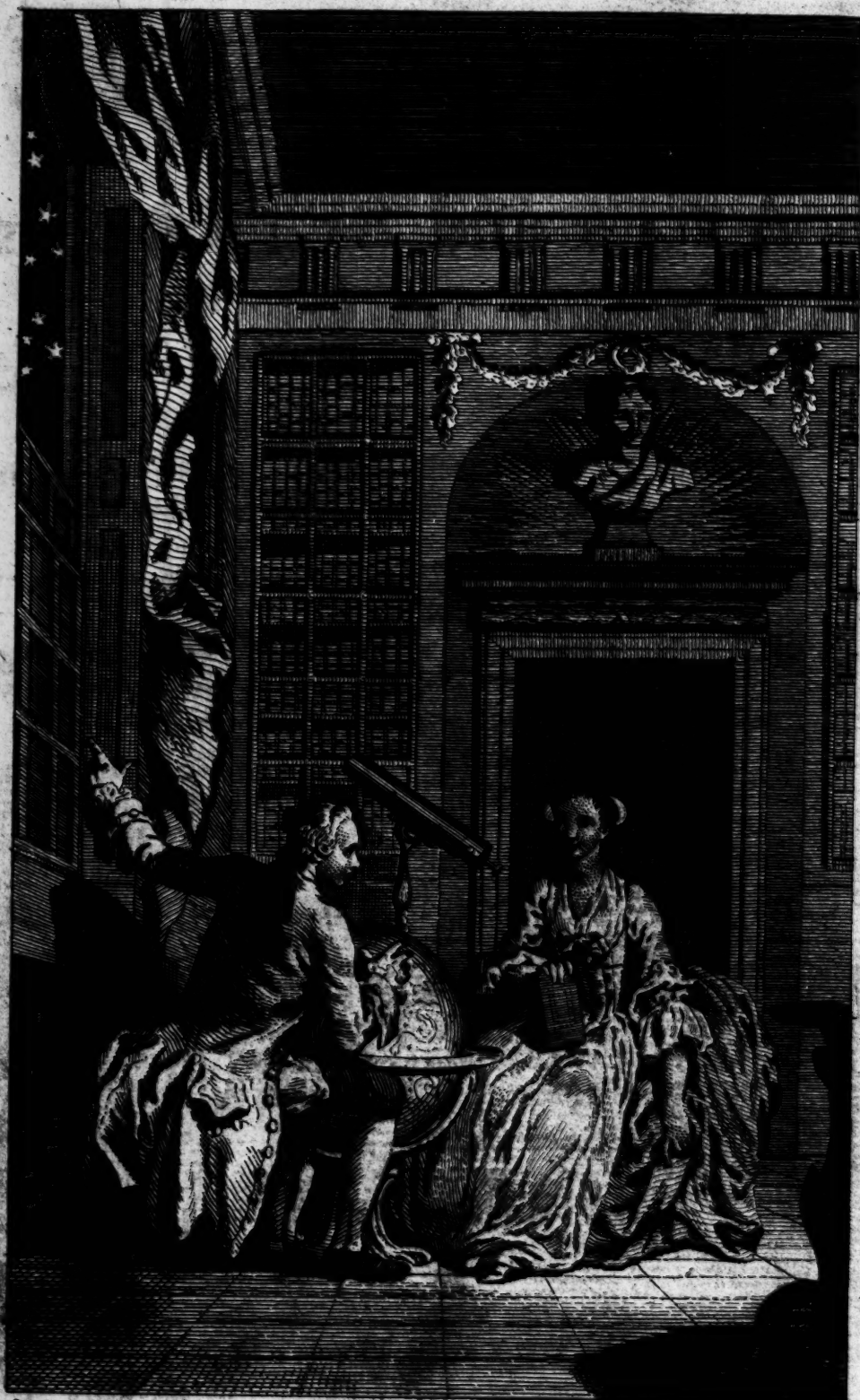
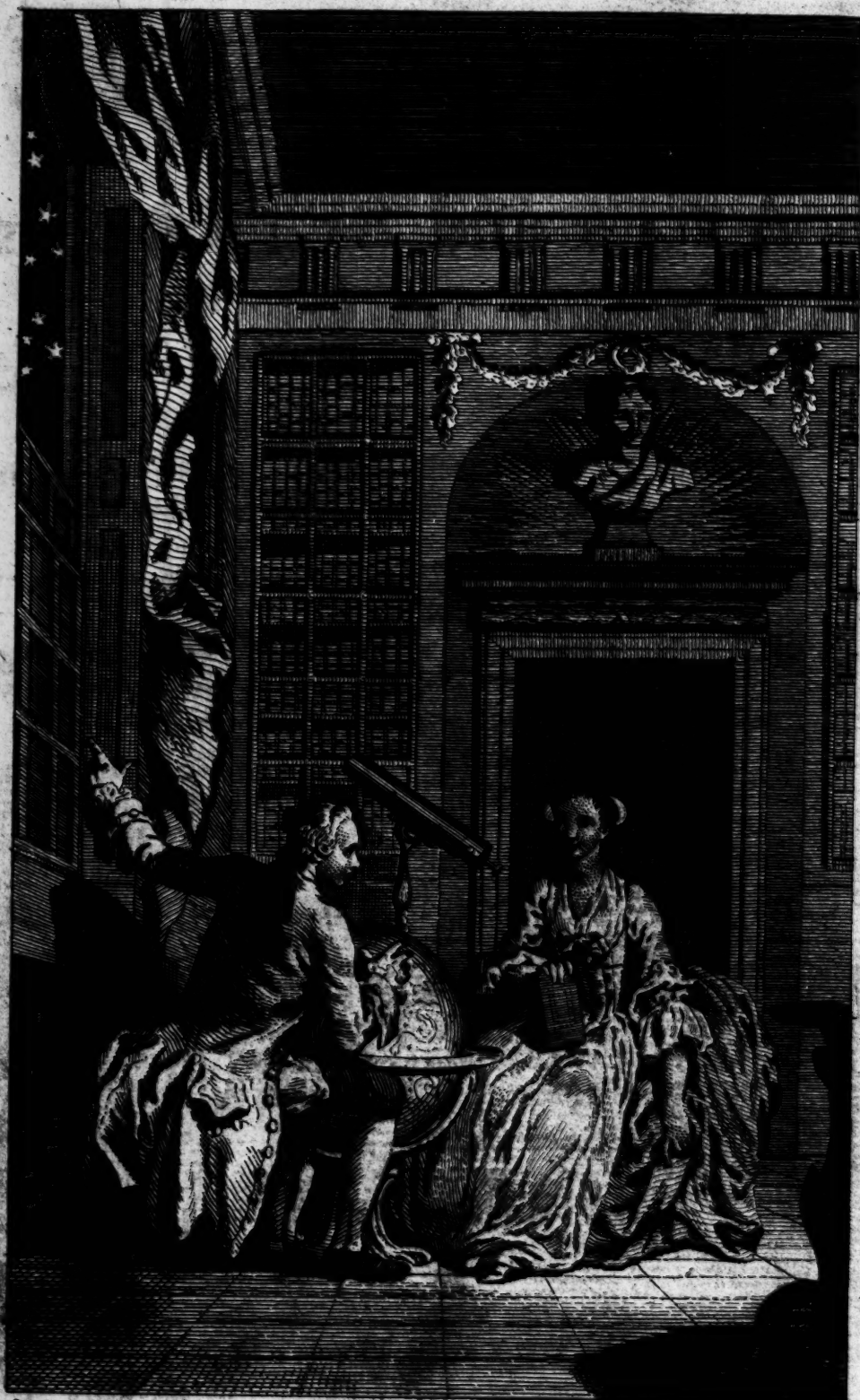




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The GENERAL
MAGAZINE
OF
ARTS and SCIENCES,
PHILOSOPHICAL, PHILOLOGICAL,
MATHEMATICAL, and MECHANICAL:

Under the following Heads, *viz.*

- I. The young GENTLEMEN's and LADIES PHILOSOPHY; or a particular and accurate SURVEY of the WORKS of NATURE, by way of DIALOGUE; illustrated by Experiments, and embellish'd with Poetical Descriptions; with an exact Account of all the Instruments used in the Philosophical Sciences.
- II. The NATURAL HISTORY of the WORLD; containing a just and particular Account of all that is remarkable in the Animal, Vegetable, and Mineral Productions of every Part of the Earth and Seas.
- III. A compleat SYSTEM of all the PHILOLOGICAL SCIENCES, *viz.* Theology, Ethics, Mythology, Grammar, Rhetoric, Logic, Poetry, Geography, Chemistry, Botany, Anatomy, Physic, &c. according to the modern Theories and Improvements.
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- V. MISCELLANEOUS CORRESPONDENCE, ESSAYS, POETRY, Remarkable Occurrences in the Month, Catalogue of Books, Prices of Stocks, &c.

By BENJAMIN MARTIN.

L O N D O N:

Printed for W. OWEN, at Homer's Head, in Fleet-street.

M D C C L V.

The GENERAL
MAGAZINE

ARTS AND SCIENCES

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THE
Young Gentleman and Lady's
PHILOSOPHY,

IN A

Continued SURVEY of the WORKS of
NATURE and ART;

By Way of DIALOGUE.

VOL. I.

CONTAINING,

The PHILOSOPHY of the HEAVENS, and of the
ATMOSPHERE.

Illustrated by Thirty-three COPPER-PLATES.

By BENJAMIN MARTIN.

L O N D O N:

Printed and sold by W. OWEN, *Temple-Bar*, and by the
AUTHOR, at his House in *Fleet-street*.

MDCCCLIX.

THE

Young's Concise and

PHILOSOPHY

IN A

Continued SURVEY of the Works of
NATURE and

BY W. B. DIAL, O.C.

VOL. I

CONTAINING

The Elements of the History and of the
Astronomy

Illustrated by Benjamin



By BENJAMIN

LONDON: W. B. DIAL, O.C.

Printed and Sold by W. B. DIAL, O.C. and by the
Author, at his House in

MDCCCXX

ON THE
USEFULNESS
OF
NATURAL PHILOSOPHY:
A
POEM.

Hoc studia adolescentiam alunt, senectutem oblectant, secundas res ornant, adversis, solatium, et perfugium præbent; delectant domi, non impediunt foris, pernoctant nobiscum, peregrinantur, rusticantur.

TULL.

O THOU! Enthron'd above the starry Orb,
Great Cause of Causes! Everlasting God!
Assist a grow'ling Worm, who feebly tries
To sing thy mighty Works in grateful Verse:
O, let a Spark of that celestial Fire,
Which touch'd ISAIAH's Lips, influence mine!
While Chaos reign'd, and Darkness cloth'd the Deep,
Th' ætherial Spirit hover'd o'er its Mass.
Hark! From the Slumbers of Eternity,
Forth from the great ETERNAL's bright Abode,
Let there be Light! The sacred FIAT rang,
And all around Light instantaneous rose!
With equal Might, in six successive Days,
The Sov'reign ARCHITECT his Work perform'd;

The Seventh beheld the new Creation smile ;
 Then rested GOD from all his glorious Toil. —
 High in the Vault of Heav'n, the central Sun
 Superior shone, in radiant Lustre dress'd,
 With native Heat to great Degree endow'd,
 And smil'd on frozen Saturn's distant Ring :
 Himself a World, amidst surrounding Worlds !
 About him, all the planetary Train
 Joyful, began their new harmonious Dance.
 In stated Periods next the Comets mov'd,
 Large, solid Bodies, with a Length of Tail ;
 Elliptical, and various in their Course,
 Still more, or less attracted by his Heat.
 Earth on her Center mov'd from East to West,
 The Third amidst the wond'rous System plac'd ;
 In all her gayest Drapery adorn'd,
 To strike the Eye, and captivate each Sense ;
 And round her mov'd the Moon's officious Light.
 Birds, thro' extensive Fields of liquid Air,
 By quick Transition, sported on the Wing,
 And sung in various Notes their Maker's Praise.
 The Streams prolific pour'd the finny Race,
 While mighty Ocean with new Monsters teem'd ;
 The Whale, with Bulk enormous to behold,
 Behemoth, and the great Leviathan,
 With ev'ry Species of the rolling Deep.
 Beasts of a thousand Kinds then trod the Plain,
 Reptiles and Insects shone in gay Attire,
 Tint'd with unnumber'd glossy Dyes, that prov'd
 Shade above Shade, the Painter's matchless Art. —
 Man then was form'd, as sov'reign Lord of All,
 More fair and wise than all the brutal Train,
 With Soul divine endow'd, stupendous Frame,
 Godlike, erect, with Reason for his Guide ;
 Reason, the Gift of great indulgent Heav'n !
 This dignifies the Man beyond the Brute ;
 This bids him hold sweet Converse with the Skies !
 He, with his Talents, and superior Sense,
 Thro' Nature takes a philosophic View ;

*While Wonders, rais'd on Wonders, strike his Eyes !
 If yon vast Vault demand his earnest Search,
 There Symmetry, magnificently great,
 Form'd by unerring Wisdom stands confess'd ;
 Where Worlds on Worlds in ample Order shine
 Thro' all the boundless Tracks of Universe.*

*Two Principles endow the Soul of Man,
 His Understanding, and his better Will :
 That, thro' a Thirst of Knowledge he perfects,
 This, by his Goodness, more ennobled shines :
 Nothing below, can more enlarge the first,
 Or raise the last, than studying Nature's Rules ;
 Rules, which observ'd, will lead to Nature's God.*

*O Man ! His much-belov'd, his darling Care,
 Ne'er let the Gifts He plenteous pours around
 For thy Delight and Use, be pour'd in vain :
 Let ev'ry Morn thy Gratitude ascend !*

*Would'st thou be rich ? — Laborious dig thy Gold,
 Dig Truth, dig Wisdom from the latent Mine ;
 Then coin, and use them for thy proper Use :
 If ought to spare, bestow on human Kind,
 And kindly shew them how to search for more.
 This shall advance thee o'er the vulgar Crowd,
 And claim Respect among the Sons of Men.*

*All hail PHILOSOPHY ! Celestial Fair !
 Sent from above, replete with ev'ry Good,
 T' improve each striving Faculty within,
 To mend our Morals, and refine the Heart.
 Without thee, what were those resplendent Orbs,
 With all the grand Appendage of the Skies ?
 Those Stars, that twinkle in the vast Expanse,
 From thy Assistance more conspicuous shine ;
 Silent they teach a Lesson to Mankind,
 And light us on to Scenes of future Joy.
 For Fruits of Knowledge, oft th' enraptur'd Mind
 From Field to Field of Contemplation roves,
 And forms from close Pursuits more gen'ral Laws ;
 Laws, which the great Phænomena explain
 Of Earth, Sea, Air, and Regions far above :*

*She cancels Limits—glowing now ascends
 From Scale to Scale of Beings, 'till she soars
 In Thought profound, beyond Creation's Bounds,
 "To the first good, first perfect, and first fair."
 From Stage to Stage, now gradual she descends,
 Beneath ambrosial Dews, the Gift of Heaven!
 Beneath the loud Applause of Angel-Hosts,
 And lights again on this terrestrial Sphere.*

*Whether this spacious Earth we traverse o'er,
 Or rove in Thought from Indus to the Pole;
 Whether we mount contemplative the Skies,
 And journey thro' Plurality of Worlds;
 Which Way so'er our darling Genius leads,
 We view the Footsteps of the DEITY!
 What rigid Sceptic boldly shall deny
 Philosophy's of gen'ral Use to Man,
 When by its Study, he more clearly knows
 The Wisdom, Pow'r, and Attributes of GOD?
 The Mists of Error puzzle Men no more,
 Such as prevail'd, when dawn'd the mystic Art;
 Experience long all Darkness has remov'd,
 And Truth breaks round us with resistless Blaze.*

*Shall We, the noblest of Creation's Works,
 From Year to Year supinely spend our Time,
 Nor once indulge a scrutinizing Thought,
 How Nature, pregnant with all Life can crave,
 Preserves, throughout, one great, harmonious Round?
 To search her Ways will more Contentment yield,
 More lasting Pleasures, more exalted Joys,
 Than all the Stores the great Peru can give,
 Or precious Diamonds from Golconda's Mine.*

*Thro' Life's short Course, what trifling Toys amuse?
 Fraught with no bless'd Advantage to the Mind;
 Tho' ever studious to enhance Delight,
 And ev'ry Day Diversion shifts the Scene:
 Each Novelty grows languid in our Eyes,
 While full Fruition palls upon the Sense;
 Beauties there are, which more refin'd can please,
 Which in more delicate Succession rise*

*From Wisdom's chaste Embrace, and stricter Rules;
Such as attend us thro' this dreary Vale,
Nor leave us, 'till we leave terrestrial Things.*

*In Youth they firmly fix our wand'ring Thoughts,
And stamp the best Ideas on the Mind;
Add Lustre to the Paths of middle Life,
Glow in the Bosom of the hoary Sage,
Crown with illustrious Worth his rev'rend Head,
And make him smile serene at Death's Approach,*

*Thro' various States Prosperity adorn:
Retreat and Comfort bounteously bestow,
When stern Adversity tremendous frowns.
Delight at Home, nor e'er disgust abroad;
They travel with us to remotest Climes,
Make ev'ry Country yield a Tide of Joy;
Attend thro' ev'ry Office of the Day,
And when the Night returns, with us repose.*

*Innumerable Uses flow to Man,
Thro' ev'ry Branch of circulating Trade,
From the just Lights which Nature's Plan affords.
With arduous Toil th' Astronomer acquires
The Frame of Heav'n, made easy to his Sight;
He views the vig'rous Sun's meridian Blaze,
The Moon, and ev'ry Star that gilds the Pole.
From hence, the Merchant, emulous of Wealth,
At proper Periods, trusts the raging Seas;
Knows when the Winds will gently swell the Sails,
When blustering Boreas sleeps within his Cave,
And either India's Stores become his own.
The grave Physician, by close Study, finds
The healing Virtues and Effects of Plants,
With all the Tribes of medicable Herbs.
With equal Care, the Chymist too attains
The Use of Metals, Minerals, and their Stores,
Prepares, dissolves, and analyses All.
Th' Apothecary happily explores
The various Simples of the fertile Field,
And calls, by nicest Rules, his Antidote,
To form his Med'cines, and restore Mankind.*

*The poor Mechanic, with Attention due,
 His Myst'ries may enlarge, and gain Applause,
 And with Applause, perhaps attractive Gold.
 Led by her Laws, the Husbandman may learn,
 At proper Times, to fertilize his Lands,
 And make his Acres yield an hundred-fold,
 A golden Crop, from Ceres' lib'ral Hand.
 In short, look round this habitable Globe,
 View Kings and Princes more illustrious shine,
 Charm'd with the Virtues of Philosophy!
 From Stations high, by just Degrees, descend,
 Thro' ev'ry State subordinate to Life,
 What Man of Reason but adores the Maid?
 For Reason still attends her ev'ry Hour,
 Thro' ev'ry Region where she takes her Flight,
 Soars when she soars, and with Devotion glows.*

PHILOSOPHY! Sure Guide to limpid Truth,
 Choice of the Wise, a Mystery to Fools,
 Who blind with Ign'rance, scorn thy winning Smiles,
 In Ages past, thou rear'dst thine honour'd Head,
 A while imperfect known——'till rolling on
 With small Improvement down the Stream of Time,
 Thy Features more refin'd, and lovely grew:
 Finish'd at length by Newton's plastic Hand,
 Philosophy commenc'd a finish'd Fair,
 Adorn'd with ev'ry Beauty, Grace, and Charm,
 To win obedient Hearts, and gain Applause.
 O, more and more extend thy gentle Sway
 O'er Virtue's favour'd Race, and bless Mankind!
 Make ev'ry Fair who crowns Britannia's Isle
 Enamour'd with thy Charms, still fairer grow;
 O, raise an Emulation, truly great,
 In ev'ry Art each other to transcend!
 On either Sex kind Nature has bestow'd
 A just Proportion of indulgent Parts,
 And form'd alike Competitors for Praise:
 From Education only, Men are found,
 By Custom taught, to claim superior Sense:
 Rise, zealous rise, assert your native Rights,

*Thro' Nature's Volume diligently pry,
And claim with us an equal Share of Fame.*

*What great, what glorious Properties has Light !
Bless'd Emanation of th' Almighty Pow'r !
The first material Link in Being's Chain !
Worthy the Fiat, that first call'd thee forth
From Darkness, and Confusion's wide Domain !
Attracted by thy Pow'r, the ravis'd Eye
Descants on all around with vast Delight ;
The Soul exults amid her wond'rous Frame,
For Man's the wond'rous Workmanship of God !
Auspicious Light ! be friendly to Mankind ;
Long o'er the Products of this fertile Globe
Display thy Charms, 'till Time shall be no more.
What various Dyes on Trees, Herbs, Fruits, and Flow'rs,
Thy Rays refracted, beauteous pour abroad !
Light to the Peach imparts the Blush it wears,
Tinges the Neck rine with a deeper Red,
Beams on the Plum that soft, inviting Blue,
And o'er Pomona's Gifts pours countless Charms :
Paints ev'ry Colour in the Peacock's Tail,
With splendid Iris, that celestial Bow.*

*How pow'rful proves the Air's elastic Force !
As on the Pump Experiments confess :
Creation's Fruits no more could wig'rous thrive,
Than Man subsist without the fragrant Balm.
Porous are all the vegetable Tribes,
And all receive fresh Draughts of vital Air,
By just Gradation to the royal Oak,
Or Cedar, which adorns the Mountain's Broom.
Our Atmosphere all pond'rous presses round
In strict Proportion o'er the Face of Things,
Yet all sustain the vast, surprising Weight,
Buoy'd by Resistance of internal Air.
The Winds from Vapours purge th' aerial Climes,
Which, otherwise, would taint both Man and Beast.
What Care has that Almighty Mind bestow'd
On these, his lower Works, Works all Divine !
How worthy our Inspection and Regard !*

*Let Pride abash'd, sink humbly to the Dust;
When we behold the same transcendent Skill
At large display'd thro' Nature's ample Field,
As in this glorious, fair Machine of Man.*

*Sing next, my Muse, what Uses flow from Sound,
Whose Medium is the wide circumfluous Air;
Caus'd by some sudden Stroke, the quav'ring Parts
Affect the Tympanum, and strike our Ears.
How soft, how pleasing to th' attentive Mind
Are Notes, arising from melodious Strings!
Artful they sooth our Troubles into Rest,
And waft the Soul beyond her native Sphere.
So David pleas'd the royal Ear of Saul,
Banish'd all Discontent, all anxious Thoughts,
And pow'ful made the Snakes of Envy sleep.
Tarantulas in vain envenom'd bite,
If Music's sov'reign Antidote oppose:
By just Degrees, th' afflicted Patient feels
No more a Numbness of his nat'ral Parts,
Enliv'ning Airs affect his whole Machine,
His Legs, Arms, Fingers, catch the thrilling Sound;
With Joy he bounds, to perfect Health restor'd.
From Concords, such great Benefits arise,
And such the Goodness of the great Supreme!*

*What Pow'r has Gravity! What mighty Force!
By which all Bodies to their Center tend;
The Sun attracts the Planets in their Orbs,
This Globe pale Cynthia gliding in her Sphere:
All teeming Matter gravitates to Earth,
Towards her Bowels, where her Center lies:
On ev'ry Form it acts with equal Force,
As much on Feathers as more pond'rous Gold!
What Qualities the useful Magnet yields,
Which constant points the Needle to the Pole;
Unless betray'd by subterranean Ore!
Without the Loadstone's necessary Aid,
The Mariner in vain would plow the Deep,
In quest of foreign Ports, in foreign Lands.
How great the Pow'r, the Wisdom, and Design,*

Of One almighty, all-creating God !
 Who form'd this World so useful and so fair,
 And from her Entrails gives such precious Gifts.

What various Scenes all wonderful arise
 From the Pursuit of Electricity !
 An Art well worthy of the greatest Praise ;
 Improv'd by Moderns thro' a length of Years.
 Like some fair Science now she lifts her Head,
 And claims a Volume to record her Use.
 Great Truths have lately been disclos'd to Light,
 While undiscover'd lie ten Thousand more,
 Which Time and Study beauteous may unfold,
 And publish wide their Virtues to Mankind:

On Themes like these the Muse could much enlarge,
 To enforce the Study of great Nature's Laws,
 And prove its Uses to the human Race ;
 But Time contracts her Song, and damps her Flight :
 A Chain of Subjects must remain-unsung,
 Fraught equal with the great Creator's Pow'r.
 Here, let some Fav'rite of th' Aionian Maids
 Assume the Theme, with Zeal divine impell'd ;
 While I, inspir'd with Gratitude and Love,
 With this Address conclude the sacred Song.

Creation's Lord ! Great Nature's glorious Guide !
 Who ever wakeful, from thy bless'd Abode,
 With piercing Eyes survey'st each dawning Thought,
 E're brought to Speech, and flowing from our Lips :
 Attend thine Ear a-while to suppliant Dust,
 Dust form'd by Thee, and form'd indeed divine !
 When Inclination prompts with warm Desires
 To search this Fabrick of the lower World,
 Direct, auspicious Guide, our Search aright !
 Or when we strive to search the Heights above,
 Curious to trace thy more surprising Works,
 Thou light us on to those celestial Scenes,
 Where Beauty, Order, Harmony conspire
 To raise Devotion, and exalt our Love !
 While second Causes studious we assign,
 Ne'er let us, mighty Lord, forget the First !

Thee,

Thee, First and Last! by whom all Things were made,
 For thy own Glory, and the gen'ral Good.
 What daring Man shall impiously attempt
 To set at naught thy great important Laws?
 Nothing in vain has thy great Hand design'd,
 Replete with all that lewish Hearts can wish.
 Shall Atheists say this glorious Fabrick rose
 From Nature only, not from Nature's GOD?
 O'reign Supreme, in Majesty ador'd,
 Extend thy Sceptre o'er the Hearts of Men;
 Crush Atheism in its Birth, from Age to Age,
 While Thou remain'st One universal Cause,
 The Father, and the Sov'reign of the World.

Reading, Nov. 26, 1758.

MARCUS,



The



To His Royal Highness

THE

PRINCE OF WALES.

SIR,

IN every Institution of Government, founded on just Principles, the Felicity of the Prince and the People must necessarily be reciprocal, as it results equally from a wise and benevolent Exercise of Dominion in the one, and good Sense, and rational Subjection, in the other: This is a Truth verified by a Reflexion on the Fate of Nations in general, but more especially confirmed by that of our own, as well in the last as present Reign, in which the Blessings of Nature have been accumulated on the *British* Nation almost to Profusion, and we may say, with more Justice than could be said of them in former Times, that the People would, if possible, be too happy were they truly sensible of their present blissful Situation in it's utmost Extent. But to do

our-

ourselves Justice, it must be allowed, we are not altogether insensible of our Happiness; for I, with the highest Pleasure, assure Your Royal Highness, that in more than half the great Towns in *England*, and among all Ranks of People, I have been a constant Eye and Ear Witness of their universal Joy and Satisfaction with their present Condition; of their extraordinary Esteem and Regard for the Person, Title and Government of his present Most Gracious Majesty, and their most exalted Hopes, and highest Confidence in their future Sovereign: This good Disposition, permit me, Great Sir, to say, is the natural Consequence of encouraging the Studies of useful Arts and Sciences, Learning and Humanity; for these furnish the Prince with Notions and Principles of Wisdom, Religion, Virtue, and Liberty, and secure the People from the Attacks of Ignorance, Barbarity, Superstition and Imposture; and in every Person they produce a rational and noble Propensity towards promoting the general Good of the Community, and the Promulgation of the Sciences among all Ranks and Orders of Men, and inculcate on their Minds Principles that will not fail to render them good Subjects: As this is the professed Design of these Papers, I humbly presume they will be acceptable to Your Royal Highness, and shall for ever esteem it the highest Honour that I am permitted to offer them to Your Highness's Inspection. That Heaven may preserve his present Sacred Majesty to the latest desirable Period of Life, and then Your Highness ascend the *British* Throne and long reign the happiest, as well as the greatest, Monarch of the World, is the incessant Prayer of,

S I R,

Your Royal Highness's

Most dutiful, devoted,

And obedient humble Servant,

B. MARTIN.

(iii)

An Account of the PLAN and DESIGN of this MAGAZINE.



THE highest Attainments of the human Mind consist in useful Knowledge, the Perfection of our Nature can only result from thence; and, in order to promote that in the greatest Degree, we must render the various Arts and Sciences as easy of Access, or the Pathway to Knowledge as direct and plain, as possible: And this, in short, is the Design of our present Publication. To effect which we shall employ our Time and Abilities in the best manner we can, and therefore presume that the Public, who are ever candid and ingenuous, will want no other Inducement to a good Opinion, and favourable Reception, of such an Undertaking.

But tho' the Merit of a Design may be indisputable, yet the manner of executing it is a Thing very material, and therefore we shall here at large lay it before the Reader; since it too often happens that the Expectation of the Public is mightily rais'd by Title-Pages, Proposals, &c. but immediately subsides upon reading a few first Sheets of the Performance.

Our Purpose is to compile and present our Readers with a *real and general Magazine of Arts and Sciences*: Concerning which it is to be observed,

First, That the Undertaking is in itself a Work entirely new; for though the Press has long groaned under the Weight of Magazines of various Complexions, not one of them has appeared with any Pretensions of this Kind, most of them being calculated for Amusement only; and as to the rest, if the Words Arts and Sciences are found in their Title Pages, you seek in vain for the Things themselves, in the Body of the Work; or if any Thing of that Sort appears, it is only by Piece-meal, in Bits and Scraps, disjointed and mangled, without Order or Connection, and therefore of no Use to any one. On the contrary, in our Magazine we propose a compleat Body of *real* Arts and Sciences; for

I distinguish between those that are *truly and really* so, and those that are not: Since it is well known that many Subjects have been ushered into the World under the respectable Names of Arts and Sciences, to the great Abuse and Delusion of Mankind. Thus, formerly, the blasphemous Jargon of *Astrology* was dignified with those Epithets; and many other Subjects are deemed Sciences, but are falsely so called, as they convey no real Knowledge to the Mind.

Secondly, The Form of our Work is intirely new; for a Body of *Arts and Sciences* has never yet been attempted in any monthly periodical Publication, under the Title of a *MAGAZINE*. And this Form we rather chuse, not only as it suits with the Humour and Taste of the present Age, but also because it will be the easiest Way to communicate Subjects of this Sort, and attended with less Expence and Trouble as well to the Publisher as the Reader; not only so, but a whole Body of Arts and Sciences poured out on the Public at once, might not perhaps be quite so pleasing and acceptable, as when retailed out in monthly Portions; for now a Person cannot think one Half-sheet upon a Science in a Month too much, as he will have Time enough to read and digest that before another comes to Hand, even in the more abstruse Arts, that require some Study and Attention: and since it will be in vain to crave for more than there can be Time to peruse and understand, it is presumed, that what has been now said, may be a sufficient Answer to an Objection that may possibly be made against a monthly Publication,—That it will be too slow, or tedious, a Performance; but we shall make no Scruple to say, that admitting a Person has a good Genius he will be allowed to make a great Proficiency if he can make himself Master of the useful Arts and Sciences in the Compass of *Ten Years*.

Thirdly, There has been no compleat System, or Body of Arts and Sciences since the new Discoveries, and great Improvements in all the Branches thereof made in the last and present Age.

The Face of Philosophy is entirely new, and a new Geometry has succeeded the old, which occasions a general Renovation in all the Mathematical Sciences; the most substantial and solid Parts of Learning have therefore now a new Aspect, and wear quite a different Dress from what they used to appear in. A general System of the Sciences, attended with so much Novelty and Utility, cannot

not now, we hope, but be very grateful to every Lover of Art and Friend to Learning.

Fourthly, The Novelty of our Method we may reasonably suppose will be another Argument to recommend it, since our Plan is to carry on the four great Classes of Science at once. Variety never fails to please in other Cases, and here it must have all its Force, since every Half-sheet of our Magazine will be pregnant with new Principles of Knowledge, and every Number will present the Reader with a gradual Progress of the Sciences, proceeding Hand-in-Hand; when he has considered the Subject of one he may apply himself to another, after that to a third and fourth, all different from each other, and each in particular such, we presume, as will be worthy his Attention, and afford him Pleasure and Instruction at the same Time. After this, by Way of Relaxation and Amusement, in the fifth and sixth Half-sheet, we shall present him with some of the choicest Pieces of Learning, Wit, Humour, Poetry, News, &c. all which we judge will be sufficient to fill up the vacant Hours of each respective Month.

Fifthly, Another great Inducement to this Undertaking is, the satisfactory Prospect we have of making the Arts and Sciences more generally known and useful to Mankind; for Experience forbids us to expect that a general Publication of the whole at once, would ever fall into so great a Number of Hands as it probably may this Way, it is not consistent with Prudence, in any Case, to overdo a Thing; People should be gradually conducted from one Apartment to the other in the Temple of Science, for since one simultaneous View of the Whole would rather tend to confuse than instruct the Mind, and deter from, rather than invite to, a particular Examination of the Parts: Things, though ever so good in themselves, by too great and sudden a Profusion, instead of exciting a Curiosity and Inclination, would probably create an Aversion, if not a *Nausea* thereto. And therefore to avoid any tendency to discourage the Study of the Sciences, we have thought it by much the best Way, to proceed in the Method of our present Plan.

We proceed now to give some Account of the Subject Matter of the Work:

I. The first Part will consist of a general Survey of the Works of Nature and Art, that is to say, we shall take a particular View of

of the several *Phænomena* of Nature, as they arise from the various Subjects that fall under our Observations, in the Heavens, the Air, the Earth, and Water, which we shall represent, illustrate and explain by the several Instruments and Machines which Art has invented, or can supply for that Purpose, and that in the most easy and natural Manner, so that the Truth and Reality of the Nature and Cause of those Appearances may be rendered quite obvious to the Understanding; for in this Part we shall propose nothing but what we may reasonably suppose all our Readers can understand: and in order to do this more effectually we shall propose it in the common Way of Experiments, since it is found by general Experience the best of all accommodated to convince the Understanding, as it consists in little more than an Appeal to the common Sense of Mankind. We oftentimes express great Diffidence with respect to our intellectual Faculties, but few People are so foolishly modest as to distrust their Senses in Cases where Objects are proposed to them in a proper Manner; and since the Senses are the general Inlets and Means of Knowledge, and are formed as accurately and just as perfect, in one Sex as the other, therefore these philosophical Subjects must be, in this Way, equally intelligible to both; consequently the LADIES may be admitted to the Pleasure and Advantage of these Speculations as well as Gentlemen, if not with more Reason, since Gentlemen have generally an Opportunity of coming to the Knowledge of these Things, in a way different from that of the Fair Sex: And therefore we have proposed it in Dialogues between a young Gentleman and a Lady in the natural and easy Way of Conversation; by which Means we hope the Instruction will be more easily conveyed, and attended with much greater Pleasure than in the common dry and tedious Dialogues heretofore written on these Subjects. Moreover, the Instruments and Machines themselves will be very particularly described, and many new ones introduced, with their Advantages and Excellencies pointed out; also Copper Plates and Diagrams will be supplied where ever they are wanted for Illustration. *Lastly*, to render the Whole as compleat as possible, we shall frequently embellish the Subject with the most beautiful Descriptions, Allusions, and Similies that can be found in the most celebrated antient and modern Poets, so that upon the Whole

Whole we hope we may be allowed, with great Propriety, to give this Part the Title of the YOUNG GENTLEMAN AND LADY'S PHILOSOPHY.

II. The second Part of our Work will consist of an entire System of the natural History of the World, or so much of the Knowledge of the natural Productions of the Earth and Sea as we have hitherto been able to discover; and here our Subject will naturally divide into several general Heads, *viz.* *First*, the Situation, Extent, Soil, Produce, Climate, Air, Length of Days and Nights, &c. of each respective Country, the Disposition and Genius of the Inhabitants, their Customs, Manners, Language, &c. *Secondly*, every thing remarkable in, and peculiar to each Country, with respect to their Beasts, Birds, Reptiles, Insects, and Fishes in the Seas contiguous. *Thirdly*, their Mountains, Springs, Rivers and mineral Waters. *Fourthly*, every thing considerable in regard to vegetable Productions, relating to Trees, Shrubs and Plants. *Fifthly*, Mines, Ores, Minerals, Fossils, Marcasites, Stones, Earths, Marls, &c. in short, every thing that History and our own Observations can furnish, deserving the Reader's Notice, relating to the Animal, Mineral, and Vegetable Kingdoms. Upon these Subjects we shall consult only such Authors whose Veracity and Credit is unquestionable, and where ever the Narrative is wonderful we are satisfied it is true; and this we shall be particularly careful about, as it is but too well known how much the World has been imposed upon by fabulous and false Accounts of Things in the Writing of antient and modern Naturalists; things enough will be found, not only to amuse our Readers but to excite their Admiration and Surprise, without having recourse to the low Arts of Imposture, Frauds and Falsity. Upon the Whole we shall endeavour to present the Reader with such a Body of natural History, both of our own and other Countries, as shall have nothing but the Marks of Simplicity and Truth to recommend it.

III. The third great Part of our Plan is intended to consist of a compleat Body of Arts and Sciences which are not Mathematical, such as *Natural Theology; Ethics, or Morality; Revealed Religion; Paganism, Mythology, Grammar, Rhetoric, Logic, Metaphysics; Poetry, Geography, Chronology, History, Physiology, Botany, Chemistry, Pharmacy, Physic; Anatomy, Mineralogy, Metalurgy, and many*

many other Branches of manual and commercial Arts, Trades, and Manufactures.

These different Kinds of Knowledge we shall treat of in the most natural, methodical and concise Manner, according to the most approved Authors, and the best Theories that our present State of Learning will furnish, and shall venture in many Places to make no small Innovations, by adding many things new and retrenching all the superfluous Parts of the old Systems; and by this Means shall endeavour to exhibit every Science in its proper and native Light: They will here no longer appear in their dry scholastic Forms, but in all the beautiful Simplicity that the genuine Principles of real Science can give them. We need not here expatiate on the Utility of these Branches of Knowledge, since it is well known that, in all Ages, and in every Nation, they have made the principal Part of Learning, distinguished by the Title of the *Belles Lettres*, though far short of that Perfection to which they have attained in the present Age, and in our own Nation in particular, these Sciences still farther recommend themselves by the Plainness of their Principles and being so easily understood; particular Talents for other Sciences are required, but these are equally adapted to every ingenious Mind, and ought to be the Study of the *Gentleman* as well as the *Scholar*, since they make the great and substantial Part of what we properly understand by a polite and genteel Education. In the last Place it must be observed, that these Sciences are not only useful to Mankind in general, but many of them such as are absolutely necessary; for what is Man without the Knowledge of Religion? Without the instructed Faculty of Reasoning? Without the Art of speaking properly and writing gracefully? Without the Knowledge of past Times and Events? Or without Skill in the fundamental Arts and Professions? From all which we may justly infer, that these are true and real Sciences, and greatly dignify human Nature.

IV. The fourth great Part will consist of a continued Series of mathematical and mechanical Institutes or Principles of geometrical Science, beginning with those that are the most simple and easy, and proceeding to the more compounded and sublime: our Readers therefore will excuse our presenting them in the first Place with the Rules of common Arithmetic, Vulgar and Decimal, as they are the first Principles of all mathematical Science;

Science; we then shall lay down a Compendium of Logarithms, whose Uses are well known to every ingenious Philomath; after these follows the Analytic Art, or the Principles and Rules of *Algebra*, then the Theorems and Problems of *common Geometry* in a new and concise Method; we shall then deliver the Properties of the *Conic Sections*; viz. the *Ellipsis*, *Parabola* and *Hyperbola*. To this will succeed the Doctrine of the Sphere, or the Principles of *spherical Geometry*. After this we propose an extensive View of the new Mathesis, which may properly be called the *Newtonian Geometry*, as it principally consists in the *Doctrine* of *FLUCTIONS*, which was entirely the Invention of *Sir Isaac Newton*, and from which the mathematical Sciences received their highest Perfection and their final Improvement. From the Institutions of *common Geometry*, considered as the Theory, we shall deduce a regular *Praxis*, or System of mathematical Sciences, such as *Mensuration* of *Superficies* and *Solids*; of Heights, Depths and Distances; *Gauging*, *Surveying*; *Navigation*, in several Kinds, plain and *spherical Trigonometry*; the Rules of *Perspective*; Projection of the *Sphere*; the Art of *Dialing*; *Astronomy*; the Principles of *Mechanics*, &c. with a practical Application in all the useful Parts of Business. And from the Institutions of the *New* or *Fluxionary Geometry* we shall give the Solution and Application of all the grand Problems relating to the Quadrature of curvilinear Spaces, the Cubature of Solids, the Rectification of Curve Lines; the Method de *Maximis* and *Minimis*, of drawing Tangents to Curves; of finding the Radius of Evolution; of finding the Points of Inflection and Retrogression in Curves; of finding the Centers of Gravity and Percussion; the Laws of Elastic and Non-elastic Bodies; of the Velocity, Times and Spaces described by Bodies in Motion; the Laws of Resistance in Fluids; the Doctrine of circular Motions and central Forces; the Doctrine of Projectiles in *Vacuo* and in resisting Mediums; the Theory of Catoptrics and Dioptrics; the physical Part of Astronomy, and various other Subjects, which only this sort of Geometry can reach, all which will be treated of in as plain and easy a Manner as the Nature of them will admit, and in a Method in many respects quite new.

V. The Thing we have next in View is to entertain our Readers with every thing curious and worth their Notice, communicated by any ingenious Correspondent, whose Lucubrations or

Essays in any Branch of Science, Wit, Humour, or Business, will be acceptable and thankfully received for that Purpose; many things in a miscellaneous Way may by this Means be convey'd with great Advantage to the Public; the Divine, the Mathematician, the Philosopher, the Gentleman, the Ladies of *Helicon* and *Parnassus*; the Critic, the Historian, the Antiquarian, the Merchant, the Mechanic, and the Manufacturer, may here find an Opportunity every Month of communicating their Thoughts for the Entertainment and Instruction of Mankind; and every such Contributor shall have the Credit and Honour of his Invention and Performance secured to him by affixing his Name thereto if he chuses it, and though we shall take Occasion now and then to transcribe such Things as we think proper for our Purpose from Pieces already in print, we shall at the same Time take particular Care to let the World know to whom they are indebted for it.

VI. In the last Place, our Magazine will conclude with an historical and chronological Memoir of all public Events of the past Month worthy Notice; the State of our own and other Nations will here appear; the Births, Marriages, Promotions, Deaths, &c. of all illustrious Persons, will be commemorated as well as the great Actions and Virtues that raised them to public Notice, and distinguish them from the rest of Mankind. A regular Account of Books published Abroad and at Home, with a short Account of the Contents of such as deserve it. The Prices of Stocks and Goods at the *Keys* in *London* and Country-markets, with every other important Article of public Intelligence.

To conclude, no Expence of Copper-plates, Diagrams, or Cuts will be spared for illustrating the several Parts of this Work, nor will the Public be troubled with any that are trivial or useless. The Materials for this Work have been long compiled and often revised and altered—we hope for the best. In many Parts of the Work the Reader will meet with the Generality of Instruments either quite new or differently constructed from those hitherto published. The subject Matter in many Places is also quite new, as well as the Method of representing it. The Pages of each Half-sheet will be properly numbered for binding up each respective Subject. In short, the Whole will be a compendious View of the Learning of the present Age in all its numerous Branches, which we shall constantly endeavour to execute to the

the best of our Abilities. To conclude, That nothing may be wanting to make every thing agreeable as well as useful, a new and elegant Letter has been cast for this Work, good Paper provided, and the best Engravers engaged. We hope every future Number will convince the Public we aim at the greatest Perfection that can possibly be attain'd to in such a Work, and we desire their Acceptance of our Labours only in Proportion to the Merits of the Performance, which will sufficiently recompence their

Most Obedient,

Humble Servant,

B. MARTIN.

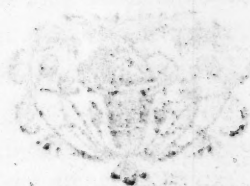


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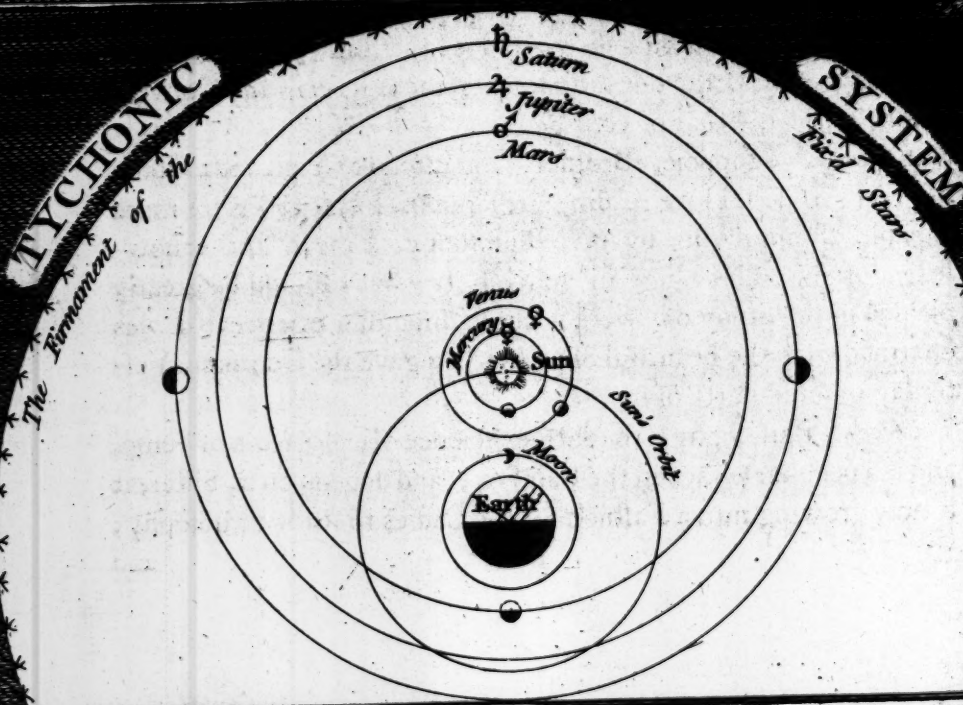
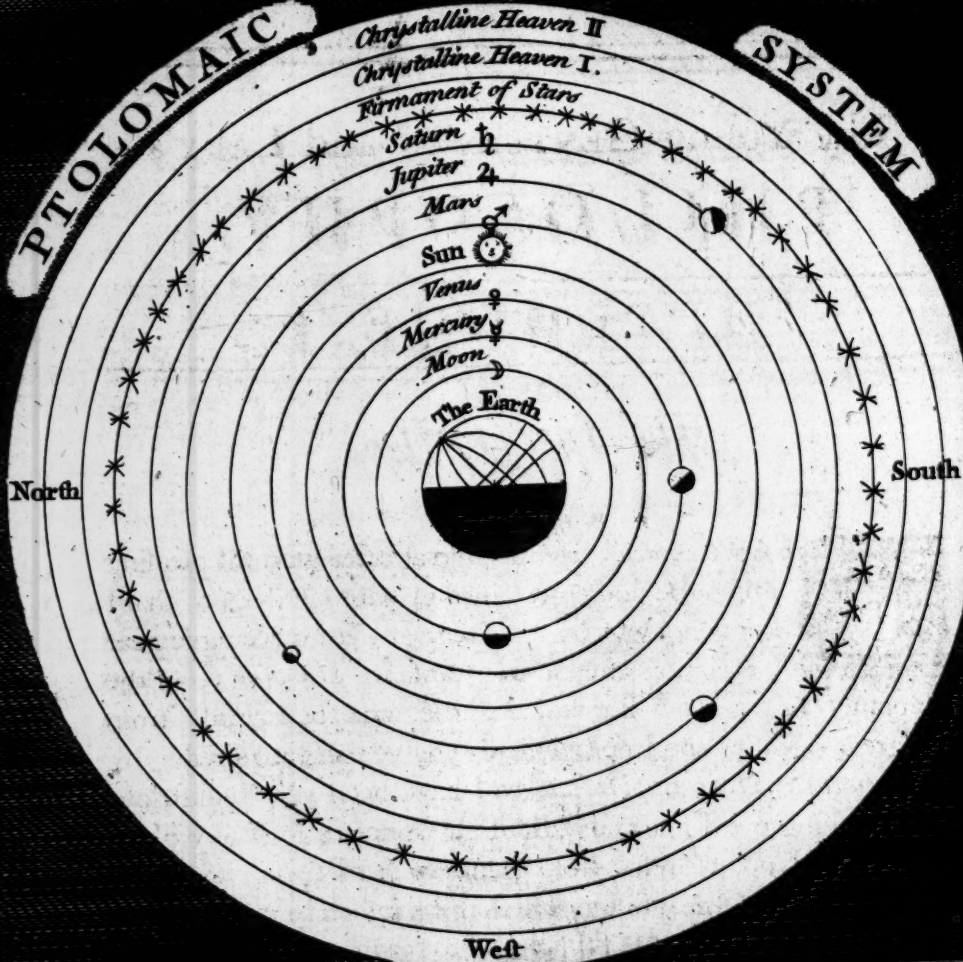
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London

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(4)

The Young GENTLEMAN and LADY'S
P H I L O S O P H Y.

D I A L O G U E I.

The Introduction.

Euphrosyne.

EAR *Cleonicus*, I've been so affected with the pleasing Discourse you entertained us with last Night, that I know not which is greatest, my Joy in seeing so near a Relation after so long Absence at College, or the Happiness I conceive will redound to me, and the Family, from the great Abilities and Improvements you've there acquired.

Cleonicus. Dear *Euphrosyne*, as I have been very industrious in improving my Time and Talents at College; so if any Satisfaction or Happiness result from thence to any Person, and especially to yourself, dear Sister, I shall think myself highly compensated. Your remarkable Disposition to reading, I see, with the greatest Pleasure, has given you an elegant Taste, and rendered you capable of Understanding, and conversing with Persons on such Subjects as come but too rarely on the Carpet in any Conversation, especially that of your Sex.

Euphros. I suppose, Brother, you intend to make me a Compliment: Indeed I love reading very much, but wish I were more capable of improving by it. Philosophy, I mean the Knowledge of natural Things in general, is what I should be greatly pleased in the Study of, were it not so difficult a Science. I was charmed with the beautiful Sketches you gave the Company Yesterday of some Parts of it.

Cleon. Philosophy is the darling Science of every Man of Sense, and is a peculiar Grace in the Fair Sex; and depend on it, Sister, it is now growing into a Fashion for the Ladies to study Philosophy;

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and I am very glad to see a Sister of mine so well inclined to promote a Thing so laudable and honourable to her Sex.

Euphros. I often wish it did not look quite so masculine for a Woman to talk of Philosophy in Company; I have often sat silent, and wanted Resolution to ask a Question for fear of being thought assuming or impertinent. I should be glad to see your Assertion verified; how happy will be the Age when the Ladies may modestly pretend to Knowledge, and appear learned without Singularity and Affectation! But can you give any Instances within your Knowledge of any Persons of our Sex remarkable for this new Cast of Thought?

Cleon. Yes, dear Sister, several; in *London*, *Oxford*, and many other Places. I shall mention in Particular, *Euprepia*, a younger Daughter of *Eugenius*, to whom Nature has not been more indulgent in *Genius*, and fine Parts, than her Father has been careful in bestowing on her a liberal and genteel Education, and she herself sedulous to improve both; so that she is now not more conspicuous for personal Charms and Beauty, than great and amiable for her singular good Sense and Judgment, in natural Sciences especially; on which Account she is admired, esteemed and beloved by all Gentlemen of Discernment. This fine Lady, you will easily judge, must be a notable Contrast to *Thelia* Daughter of *Philargus*, who, being of a sordid and contracted Temper, has bestowed no more Education on his Daughter than Marking and making of Pasties; thus *Thelia* lives admired by yeomanly Boors.

Euphros. Indeed 'tis Pity there are so many young Ladies in *Thelia's* Case; 'tis certainly more their Parents Fault than their own: *Thelia* might have been *Euprepia*, had *Eugenius* been *Thelia's* Father. 'Tis our Part, *Cleonicus*, to bless God, that we had no *Philargus* to our Parent.

Cleon. 'Tis justly observed, *Euphrosyne*, and I often do: 'Tis our Happiness that we have Parents whose Fortune enables, and whose Temper inclines, them to bestow on us Education, and to train us up to truly honourable and polite Life. I have all the Advantages of the University, and you of the Boarding-School; while I pursue the several Studies of the *Latin*, *Greek* and Mathematical Literature, you apply to *French*, and the delightful Acquisitions of the *Belles Letters*.

Euphros.

and LADY'S PHILOSOPHY. 3

Euphros. Dear *Cleonicus*, 'tis indeed my Happiness to have divers Masters and Tutors, as well as you; of one I learn *French*, of another to draw, a third teaches me Musick, and a fourth Dancing: But among 'em all there's none well enough skill'd in Philosophy to teach that in our School, were any of the young Ladies disposed to learn; this I have learned by Enquiry of my Mistresses.

Cleon. As for *Masters in Philosophy*, 'tis a thing as yet unheard of in private Schools; in the Universities there are indeed *Professors of Philosophy*, who sometimes read Lectures on that Subject; but since I have the Pleasure to find in you a Disposition to Philosophizing, I must tell you, that the only Way, at present, to learn Philosophy is from Books well wrote on that Subject. And then——

Euphros. But, give me leave to interrupt you a little, by asking you a Question; tho' indeed I am destitute of a Master, I am not of Books; my Father's Library, replenished with the choicest Books on that Subject, is always, you know, at my Command: But then, this constant Difficulty occurs, that they are, for the most Part, unintelligible, by reason either of Schemes, or hard Terms, or abstruse Reasonings, &c. Pray how am I to be relieved or assisted in such a Case without a Master?

Cleon. Dear Sister, 'tis the Fate of that Science to be attended with some Difficulties in the Study of it; these are no other ways to be removed than by the Assistance of learned Men and Books. But those Parts of Philosophy which are perplexed with Schemes and Abstrusities, are generally such as may be either wholly neglected as useless to the generality of People; or else may be explained in a more easy and familiar Manner by Experiments. Fear not, *Euphrosyne*, the greatest and most delightful Part of this Science is within the Ladies Comprehension.

Euphros. You give me good Encouragement, Brother; I wish you may find the Success of my Enquiries answerable; for I can assure you, I shall ask you many impertinent Questions on this Subject before you return again to College.

Cleon. Not more, my dear *Euphrosyne*, than I shall be as glad to answer, if I can; but don't call 'em impertinent; or else know,

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that, in the Sciences, such Impertinencies are the first Steps to Knowledge.

Euphros. Dear *Cleonicus*, you are very obliging; but suffer me to discover to you one Thing farther —

Cleon. Yes, dear Sister, I'm impatient to hear you.

Euphros. Be assured, then, that some Time before you came Home, while yet the happy Moments were near approaching, I had form'd, to myself, a Resolution to pursue the Studies of Philosophy, in somewhat of a Method, under your Instructions when present with us. — 'Tis only to you, my *Cleonicus*, I may thus speak without blushing.

Cleon. Modesty, a most amiable Virtue in all, should never be an Obstacle to the forming, or prosecuting, any great, noble, or laudable Design; 'tis then a Fault only when Ambition is a Virtue. I am extremely pleased to understand your Purpose, and shall be glad to assist you all I can.

Euphros. Indeed I design to make a direct Business of it, while you are here; and therefore you may expect me to be as troublesome as you please. — 'Twill be best making Hay while the Sun shines.

Cleon. All Opportunities and Occasions shall be employed to oblige a Sister so dear to me as *Euphrosyne*. The Severities of Winter are now past; the Days are lengthening, the Sun renews his Warmth and Splendor, the Trees begin to bud, the Birds to sing, and all Things now appear in the Serenity of a returning Spring; I therefore propose to spend those vernal Evenings in familiar Discourse on natural Things, while we walk round the Park, or over the Fields and Meadows, which make such a delightful Landscape all about us.

Euphros. If I mistake not, this is somewhat like the Manner in which the Ancients taught and learned Philosophy, is it not?

Cleon. Yes; and you have read at the same Time, that *Aristotle* and his Disciples were called *Peripatetics*, from their Custom of teaching and disputing as they walked.

Euphros. I have also read of that Sect called *Academists*, but have forgot on what Account they have that Name.

Cleon. You will easily recollect, that it was from a Place called *Academia*, a pleasant Grove at *Athens*, in which *Plato*, and his Followers, taught Philosophy.

Euphros.

Euphros. I have not read much on the ancient Philosophy, but I suppose that must needs come far short of the Modern.

Cleon. Very far short, indeed; the Difference is not much greater between Dreaming and Reasoning; between the crepuscular and the Noon-tide Light. The *Platonics* taught little more than some faint Notions of the *Deity*, which they called *Theology*; and the Doctrines of *Virtue* and *Manners*, which they called *Ethics*, or *Moral Philosophy*. Soon after *Aristotle* enquired into the Causes and Nature of Things, but made no great Discoveries, as being destitute of the proper Means, *viz.* Instruments and Experiments; for which Reasons that Science which is properly called *Physics*, or *Natural Philosophy*, was brought to no Perfection 'till within these 200 Years, or, I may more justly say, 'till within these last 50 or 60 Years.

Euphros. Indeed I have often observed in the little Compass of my Reading that many great and useful Inventions have been ascribed to several modern Names, as *Bacon*, *Boyle*, *Libnitzs*, *Newton*, *Boerhaave*, *Halley*, &c. and have as often wondered how those Things should remain undiscovered so long.

Cleon. The true Reason was, as I said, for Want of a right Method of Philosophizing, and proper Means to conduct them in their Pursuits; add to this, their Pride and Arrogance would not suffer them to appear ignorant of any Thing, and consequently (not daring to appear in a Posture of Enquiry) they knew little or nothing of the true Nature of Things. 'Twas my Lord *Bacon's* great Soul which first pointed out the Way to real Knowledge, and the Hon. Mr. *Boyle* indefatigably pursued it in numberless Experiments, and discovered the true Nature of the Air. Sir *Isaac Newton*, Dr. *Wallis*, &c. first improved the mechanical and mathematical Parts, and brought Astronomy to its greatest Perfection. The learned Dr. *Herm. Boerhaave* made great Discoveries in Chemistry and the Nature of Plants and Minerals; and Mr. *Lewenhoeck*, that great Improver of the Microscope, first brought to Light the invisible Parts of Nature; the Theory of the Winds is now well nigh perfected by Dr. *Halley*, lately deceas'd. And lastly all the valuable Curiosities and wond'rous Productions of Nature, are to be seen in the unparelled Collection of the late Sir *Hans Sloane*, and in the Museum of the Royal Society.

Euphros.

6 *The young* GENTLEMAN

Euphras. Since you mention the Royal Society, pray let me ask you one Question: What are those called the *Transactions* of the Royal Society, I have never yet seen them, though I meet with perpetual References to them in every modern Piece of Philosophy?

Cleon. They are a Sort of Register or Journal of all the notable Experiments, Discoveries, Enterprizes, learned Discourses, &c. which are constantly made by the Members of that Society at their several Meetings; and which are published in particular Numbers for the Promotion of Natural Knowledge, and the various Arts and Sciences among Mankind. These Numbers are now very many, but are abridged by several Hands, for more general Use; and as they are the Treasury of natural Science I design to make you a Present of them, to assist and encourage you in your intended Studies therein.

Euphras. Dear *Cleonicus*, your Kindnesses to me are such as I can never requite, but with the sincerest Love and Esteem; they endear you to me in all the Characters of a Brother, a Friend, and a Tutor. But, as the Evening is now well spent, let us defer our farther Thoughts to the next convenient Season.

Cleon. 'Tis true, my *Euphrasyné*, the Night, and Nature, calls us away to rest. The next Time we discourse of these Matters, we will take a regular Method of contemplating Nature; survey first the *Heavens*, then the *Air and its Meteors*; after that we will take a View of the Earth on which we live, and all its various Productions; and lastly, we will recreate ourselves with the delightful Discoveries of the Microscope, and other curious Instruments by which Philosophy has arrived at its present great Perfection. In the Course of these Meditations, we shall (in the Words of Sir R. Blackmore)

*See thro' this vast extended Theatre,
Of Skill divine, what shining Marks appear!
Creating Pow'r is all around express'd,
The God discover'd, and his Care confest;
Nature's high Birth her heav'nly Beauties show,
By ev'ry Feature we the Parent know.
Th' expanded Spheres, amazing to the Sight,
Magnificent with Stars and Globes of Light;
The glorious Orbs which Heav'n's bright Host compose,
The imprison'd Sea, that restless ebbs and flows;*

The

*The fluctuating Fields of liquid Air,
With all the curious Meteors how'ring there,
And the wide Regions of the Land proclaim,
The Pow'r divine that rais'd the mighty Frame.*

Creation. Pag. 5.

DIALOGUE II.

*Of the UNIVERSE, and the several SYSTEMS of the
WORLD.*

Cleonicus.

I Guess at your Wishes, Sister ; this fine Day terminates in a fair and delightful Evening, which invites us to the Pleasures of a Walk ; you are ready to go, but which way are you inclined to take, the Park or the Fields, or along the winding Lanes ?

Euphrosyne. The Park this Evening, if you chuse it, Brother.

Cleon. With all my Heart, *Euphrosyne* ; come on, and while we take a Tour about the large extended Plain, ask me any Questions your Curiosity may suggest, and I'll endeavour to answer them the best I can.

Euphros. I thank you, *Cleonicus* ; I remember when we last discoursed together, you promised me a regular Account of natural Things, and said we should begin with the *Heavens* ; this seems an ambiguous Term to me, pray, what do the Philosophers mean by *the Heavens* ?

Cleon. They sometimes mean, the Sky or Firmament ; sometimes the Orbits of the Planets ; sometimes the Space of one System and sometimes of all the Systems in the Universe.

Euphros. That I may have a yet clearer Idea of what you intend, I must beg you to explain the Terms *Universe*, *Systems*, *Space*, &c. for I would willingly understand Things aright.

Cleon. By the *Universe*, my *Euphrosyne*, you are to understand the whole Creation of all Things, together with the every Way infinitely extended Space or Void in which they have their Existence.

Euphros.

8 *The young* GENTLEMAN

Euphros. If, as you intimate, the Universe be infinite, how do you think it is furnished in the several Parts thereof, or is it all an empty Space beyond the Stars?

Cleon. The Philosophers of the present Age teach us, that the Universe through all the boundless Space, is replenished with Systems or Worlds of different Bodies. For by a *System*, they mean a Number of Bodies which move about one common Center or Point; and such a System is what we call a *World*; and the moving Bodies of these Systems, we call *Planets* and *Comets* in ours.

Euphros. Do the Philosophers know any thing of the several Systems or Worlds besides our own?

Cleon. Not any Thing certainly; they only make probable Conjectures at most, and reason from the Analogy they observe between some things in our System, and some in theirs, which they think alike; of which I shall be more particular when we talk of the Stars?

Euphros. You know best, dear *Cleonicus*, how to direct my Enquiries; I am content therefore if I can but obtain a general Knowledge of our own World; but what did you say, that all the Bodies of our World were moveable about a Center?

Cleon. Yes, all but one; and that one is it which possesseth the Center or middle Point of the System.

Euphros. Before I can ask you a Question I intend, you must, *Cleonicus*, tell me how many Bodies there are which compose our System or World?

Cleon. Those whose Number is certain are, of the larger Sort, Six; viz. *Mercury*, *Venus*, the *Earth*, *Mars*, *Jupiter* and *Saturn*, besides the *Sun* which is far greater than them all. But those Bodies we call *Comets*, or *Blazing-stars*, are still more, tho' uncertain in Number. Besides all these, there are a lesser Sort of Bodies in our System which move about the larger, and they are called *Satellites* or *Moons*, of which we can see but one with the naked Eye.

Euphros. But, dear *Cleonicus*, are not the Stars which twinkle all about us, and light us through gloomy Nights, a Part of our System?

Cleon. No; the Reason of which you will understand by-and-by.

Euphros.

and LADY'S PHILOSOPHY. 9

Euphros. Then the Question I would ask, is; which of all those Bodies you mention is That which remains at rest in the Center of the System?

Cleon. That is the Question, indeed; you will not a little wonder, perhaps, to hear, that the most learned Philosophers have been controverting this Point for above 2000 Years; Schools have disputed with Schools; and many, and different Systems have been formed to solve the Appearances and Motions of the heavenly Bodies.

Euphros. I have read, I remember, of the Systems of *Ptolomy*, *Tycho*, and *Copernicus*; I suppose you mean these among the rest, do you not, *Cleonicus*?

Cleon. Yes, my *Euphrosyne*, those which you mention are the Principal; beside which there were some others, as of *Kepler*, *Descartes*, &c. from such a Variety of Notions, *Sir Richard Blackmore* says,

The old and new Astronomers in vain

Attempt the heav'nly Motions to explain.

But here *Sir Richard* was mistaken; for the new Astronomers have very successfully explained the heavenly Motions in every Respect.

Euphros. Tho' it may not be to much Purpose to have a large Account of all these Systems, yet I should be glad just to know what they were, and how they differed from each other, in as few Words as you can.

Cleon. The System of the famous *Egyptian* Astronomer, *Ptolomy*, was the most gross and vulgar: He supposed the Earth possessed the Center of the World, and that about it moved, first the Moon, then *Mercury*, then *Venus*; then the *Sun*; then *Mars*, *Jupiter* and *Saturn*; all in Orbs above each other; next above *Saturn* he placed the Firmament of the fixed Stars; and above these, two solid crystalline Spheres, one moving from East to West, the other from North to South, and *vice versa*. All these he included in that Sphere he called the *Primum Mobile*, or first Mover, which, by a daily Motion about its Axis, carried the inferior Orbs from East to West once in 24 Hours. But this Hypothesis was far from solving the Appearances of the heavenly

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Motions,

10 *The young GENTLEMAN*

Motions, and therefore is deservedly thus censured by the aforesaid Gentleman.

*First Ptolomy his Scheme celestial wrought,
And of Machines a wild Provision brought.
Orbs centric and eccentric he prepares,
Cycles and Epicycles, solid Spheres,
In order placed, and with bright Globes inlaid,
To solve the Tours by heavenly Bodies made.
But so perplex'd, so intricate a Frame;
The later Ages with Derision name.*

This System you have represented in the Diagram I have drawn for you, (*Plate I. Fig. 1.*) and is evident by Inspection only.

Euphros. It is so; it is the Figure of the Heavens, which I have seen in every common Map. But since *Tycho* disapproved of *Ptolomy's* System, I suppose he advanced one more plausible; pray, what was peculiar to his?

Cleon. 'Tis said, he placed the Earth in the Center of the System, and gave it only a diurnal Motion about its Axis once in 24 Hours; tho' some say, he made the Earth to be absolutely at rest. About the Earth he revolved the *Moon*, and also the *Sun*, but then about the Sun he placed the Orbs of *Mercury*, *Venus*, *Mars*, *Jupiter* and *Saturn*; so that they revolve at the same Time about the Earth once in a Year. Thus Sir Richard:

*The famous Dane, who oft the Moderns guides,
To Earth and Sun their Provinces divides;
The Earth's Rotation makes the Night and Day;
The Sun, revolving thro' the ecliptic Way,
Effects the various Seasons of the Year:
Which, in their Turn, for happy Ends appear.*

This enormous Construction of a System of the World I have represented also in a Scheme, for your more easy apprehending it. (*Fig. 2.*)

Euphros. I am obliged to you for it, as it is not quite so easy to get an Idea of it without. This Scheme of the Heavens, if I remember

and LADY'S PHILOSOPHY. II

member right, is also exploded; but I forget the particular Reasons thereof.

Cleon. Because in this, not only single Planets, but a whole System is made to revolve about the Earth every Year; which is an Effect so prodigious to answer an End much easier brought about by a more simple and natural Contrivance, that it has been justly rejected by the *Moderns*, who all agree to admit the *Copernican System* as the only true and genuine one, of which we will hereafter discourse more particularly.

DIALOGUE III.

*Of the fallacious Reasoning on which the PTOLOMAIC
HYPOTHESIS depends.*

Cleonitus.

WE last Night had a pleasant Walk, in which I gave you a general Account of the *Ptolomæan* and *Tychonic* Systems; and as this Evening is like to prove very serene, if it be agreeable to you to take a Walk (after Tea) to the *Villa* beyond the Park, we will re-assume the Subject of the *Ptolomæic System*, and consider a little more nicely the Merits of it.

Euphros. With all my Heart, *Cleonitus*; and I should be glad to know the particular Reasons why this System comes into such Discredit among the Learned, when it seems, for the most part, agreeable to the Senses, and is often mentioned in the Holy Scriptures.

Cleon. Neither of those Arguments you now mention, my *Euphrosyne*, have any Weight with Gentlemen of Learning, nor yet with Ladies of good Sense; and you'll find yourself able, with a little Reflection, to see they are not only absurd, but even ridiculous; for you may as well think every Thing true you hear, as that every Thing is just as you see it.

Euphros. If we are not to believe our Senses, *Cleonitus*, pray, why were they given us, and by what are we to be informed?

Cleon. Our Senses are the general Means of Information, but they are all deceptive in some Measure; none more so than

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the Sight. My dear *Euphrosyne*, you will find it a dangerous Thing to trust your *Eye-sight* too far; our rational and discerning Faculties were given us for rectifying the Ideas of Senses, and to discover Truth from Error. And herein consists our Pre-eminence above Brutes. But to come nearer the Point. To suppose the *Earth at Rest*, only because it appears to be so, is the weakest Thing a Person can be capable of that pretends to any Reason at all.

Euphros. Why, *Cleonicus*, you seem very serious, and almost warm; if People are deceived by their Senses, and imposed upon by their Professors, how can they help it?

Cleon. Very easily, my *Euphrosyne*, let them think and reason, and they will not be any longer the Dupes of Error and Imposture. A common Sailor, who has little Reason enough in most of his Actions, would yet be ashamed of such an Absurdity, as to conclude his Ship was at Rest, because it appears to be so to every one within it. And therefore, Sister, when you are disposed to take a Voyage to *France*, you will have an Opportunity of being convinced that Bodies in Motion will appear to be at Rest, and Objects at Rest appear to move, and so you will have no farther Difficulty in that Affair.

Euphros. Dear *Cleonicus*, I hope you will find some more agreeable Way to convince me, than by sending me to Sea; for though I should like to make the Tour of *France*, and to acquire philosophical Experience in the Voyage; yet I cannot, by any Means, think of the terrible Element of the Ocean.

Cleon. Well, though it might answer a very good Purpose for you to see *Paris*, especially as you might then convince the *Madames*, that the *English Ladies* excel them as much in Genius and Faculties of the Mind, as They do them in the Frillery of Dress, and personal Decorations: Yet, to save you all this Trouble, we need only take a walk to yonder Hill, and our Purpose will be answered every whit as well.

Euphros. Indeed! *Cleonicus*; I shall gladly chuse that Method rather than the other; but, pray, what curious Spectacle will there offer to confute such a general Argument?

Cleon. Come with me, and you will soon see, my *Euphrosyne*:—You observe a Wind-mill is there placed on an elevated Ground, and that there is a Ladder by which you ascend to the Door,

and LADY'S PHILOSOPHY. 13

Door.—Do you go up, and I will follow, when I have spoke a Word to one of the Millers.—Well, I see you are seated, and surveying the several Parts of the Machine; pray, how do you like being in a Wind-mill?

Euphros. Very well; I never was in one before; there is something novel and strange in the Structure, and I am greatly entertained with the Oddity of my Situation; but what amuses me most of all is, the *Motion* of that large square upright Post; see, how fast it moves round!

Cleon. The Post move, Sister; I see no Motion of a Post.

Euphros. Not see the Post move, *Cleonicus*! What has happened to you all at once, I hope you are not blind, can you see me?

Cleon. Yes, my *Euphrosyne*, with Pleasure I see, and hear you too; but I see no Post move, really.

Euphros. Well, this is the most wonderful Thing I ever knew; for it has continued to move ever since I have been speaking to you about it, and I never saw any Thing plainer in my Life than I see it move now. How is it, Brother, that you cannot see it likewise? I am amazed!

Cleon. You'll be further surprized, *Euphrosyne*, when I tell you, that though I see no Post move, I see the Mill itself move, and that I suppose is more than you can see; is it not so?

Euphros. Truly it is; the Mill move! I should not have thought of it, *Cleonicus*. I sit as perfectly at Rest here as I do in the Parlour at home, and see no Motion in any Thing but the Post; or is it all Enchantment? But hold, I recollect what you said by the Way; I believe I have discovered the Plot.

Cleon. I dare say you have; the End of your coming here is very well answered. You hereby see how very *fallacious the Sight is*; you saw the Post in Motion, and the Mill at Rest, as you thought; but now look out at this little Window, *Euphrosyne*, and you'll see the whole Reason of such a strange Illusion; observe *Rotato* the Miller, by means of that strong Lever, turning the Mill round its Axle, or upright Post, which, when you go down, you'll see is fixed immoveably in the Earth; this they always do to set the Sails against the Wind. And this *real Motion* of the Body of the Mill causes that very curious, and indeed, wonderful, apparent Motion of the *Swivel-post*.

Euphros.

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Euphros. I am perfectly convinced by this Instance of the *Deception of Vision*; I could never have thought it was possible in so great a Degree: I shall hence-forward have Reason to be more diffident, or less positive, with respect to common Notions and sensible Appearances.

Cleon. Very good, my *Euphrosyne*, it was for these Purposes I brought you hither. You will now readily grant the Earth may appear to be at Rest, and yet really move, and that the daily Motion of the Sun, Moon, and Stars may not be real but apparent.

Euphros. I am fully satisfied upon that Head:—But what must I reply to those who so religiously object the Scriptures mentioning the *Motion of the Sun*, and the *Earth at Rest*?

Cleon. Very little will suffice for an intelligent Person, and there is no reasoning with others.—As the Pen-men of the Scriptures never designed to give us a System of *Philosophy*, or *Astronomy*, (which very probably they none of them understood rightly) so they every where accommodated their Discourse and Manner of speaking to the common Understanding and Apprehensions of the Vulgar. And indeed, it would be extremely absurd to act otherwise. Sir *I. Newton* always said the *Sun rose and set*; and had he been in *Joshua's* Place would have said as he did—*Sun, stand thou still, &c.* Besides, how weakly do we argue from the literal Expression of Scripture? Does it not say, in one Place, that the *Earth is supported by Pillars*? And in another, that he (*viz.* God) has *hung the Earth upon nothing*? How contradictory are such Expressions! And indeed, this Method of treating the Scriptures is not only injurious to the Sciences, but even to Religion itself.

Euphros. You have said enough to satisfy me upon that Head, *Cleonicus*; and as it is far in the Evening, and we have a long Walk over the Park, let us set out; and when we come home, I shall be farther inquisitive about this Matter.

Cleon. As much as you please, Sister; I fear it will be too cold for you; put the best Foot foremost, and we shall soon be at home.

Euphros. I do not think of the Cold; my Head is employed about the Mill;—but, among all the bright Stars that light us home, how many Planets do you see, *Cleonicus*?

Cleon,

and LADY'S PHILOSOPHY. 15

Cleon. There are no less than three which offer themselves this Evening to the View, but one of them (*i. e. Mercury*) is now set; the bright *Evening-star*, which you see low in the western Hemisphere, is the Planet *Venus*; and that pale-faced Planet which you see yonder, *South by East*, is *Saturn*; and all the rest are *fixed Stars*.

Euphros. So the *Evening-star*, that every Body takes so much Notice of, is a *Planet*, I find; pray, *Cleonicus* how am I to know a *Planet* from a *Star* at any Time?

Cleon. Very easily, Sister, two ways; one is, that every fixed *Star twinkles*, but a *Planet* never does.

Euphros. Indeed; pray what can be the Reason of that, *Cleonicus*?

Cleon. The *Stars* are only *lucid Points* to Appearance, and therefore any opaque Atom, or Particle, floating in the Air, is sufficient to *eclipse*, or cause a *momentary Occultation* of them; and this, joined with the Agitation or Tremours of the Air, will cause that constant *Twinkling* in the *Stars* which you see: But the *Planets*, though small, are still bigger than those *Motes* to the Eye, and therefore their *Light* will suffer little or no *Diminution*.

Euphros. Very good; and what is the second Thing that distinguishes a *Planet* from a *Star*?

Cleo. This, my *Euphrosyne*, is the proper *Criterion* or Characteristic of a *Planet*, namely, a *Planet* is always in Motion from one Part of the Heavens to another, and from thence it is called a *Planet*, which in *Greek* signifies a *wandering Star*; now the other *Stars* are all fixed, and keep the same Distances constantly from each other.

Euphros. Dear *Cleonicus*, you have thoroughly prepared me to distinguish the *Planets* from the *Stars*.—I have one more Question to ask you, and that shall be all for To-night; what is the Sky or Firmament? And why does it appear always of that equally round Form?

Cleon. The Sky, my *Euphrosyne*, is not any Thing real, but only the apparent Boundary of our Sight; Space is every Way infinitely extended; but our Sight is terminated all around us, at a small, but equal Distance; and this is the only Reason why the Firmament appears of a perfectly spherical, concave Figure;

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gure; for the Surface of a Sphere is every where equally distant from the Center, and every Man's Eye is the Center of his View; could he see farther one Way than another, the Heavens would appear of an irregular Form, and quite different from that beautiful Hemisphere, or azure Canopy, which constantly represents itself to our View.

Euphros. Well, *Cleonicus*, how happy it would be if every Walk I took for the future were to prove so delightful and instructive as this! But see,—the Candles are lighted, and Supper, I suppose, on the Table; we are at Home just in Time.

Cleon. We are so; but we will now solace ourselves with the Refreshments of kind Nature, and To-morrow re-assume this Subject; for many Things remain for my *Euphrosyne* yet to understand.

DIALOGUE IV.

*A View of the demonstrative Proofs of the FALSITY of the PTOLOMAIC HYPOTHESIS, as represented in a NEW PLANETARIUM.**

Euphrosyne.

THIS Morning, *Cleonicus*, I remember you told me we should be employed, in a more particular Consideration of the *Ptolomaic System*; pray, in what Respect do you mean?

Cleon. I mean, my *Euphrosyne*, to point out to you those particular *Phænomena* of the Heavens, which are easy to be observed by yourself, or any one, and which do of themselves separately evince the absolute Falsity of the aforesaid System; and you'll not be displeased to have it easily in your Power to refute an Hypothesis in half an Hour, which has been universally and strenuously maintained for Ages past.

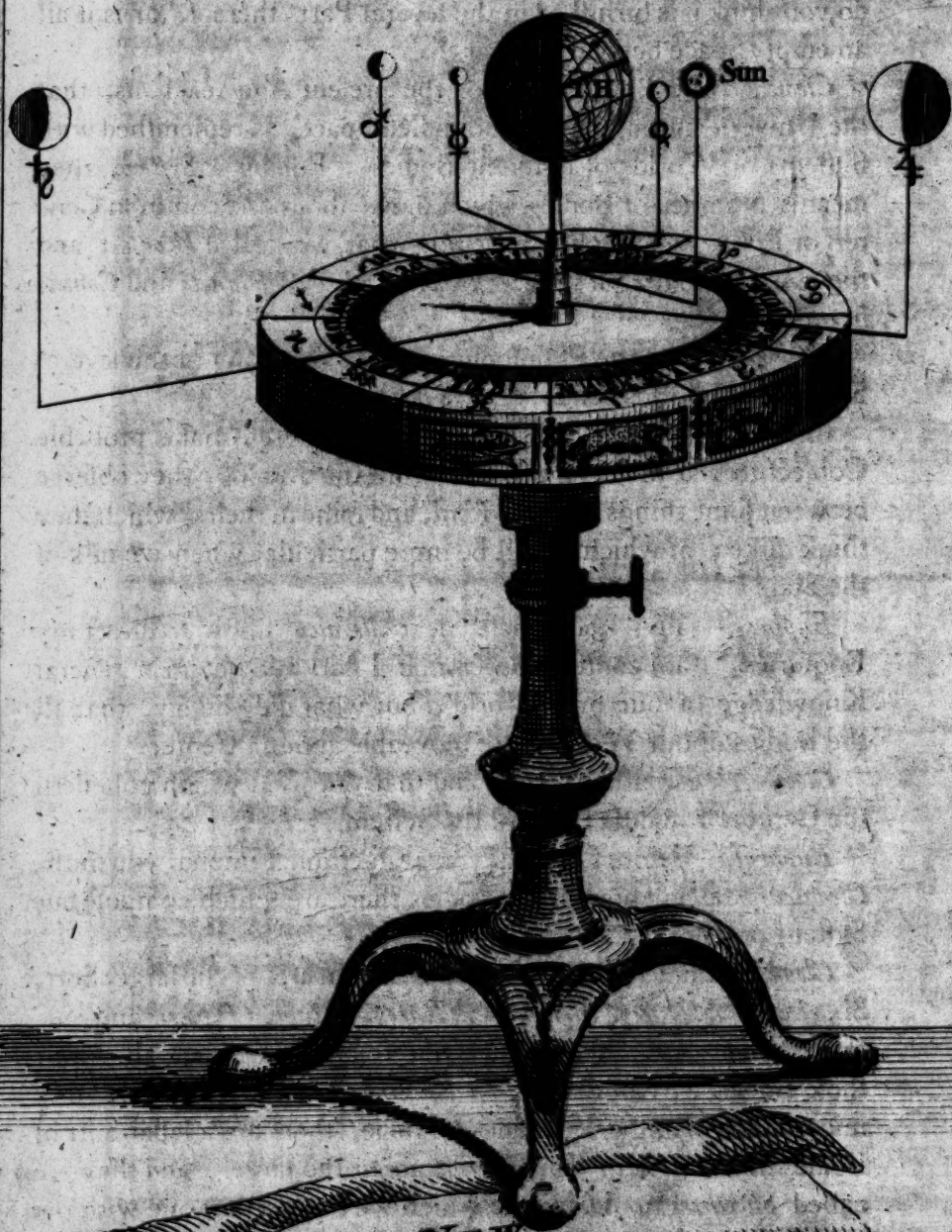
Euphros.

* The Reader, through this whole Dialogue, is to suppose, that the *Ptolomaic System* is represented by a new *Planetarium* with all the planetary Bodies, together with the Sun, revolving about the Earth at Rest in the Center; which Machine is represented in a general Manner in *Plate II.*

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A NEW
PLANETARIUM

*Shewing the various Phenomena
of the*

PTOLOMAIC SYSTEM

*Invented & delineavit.
B. Martin.*

Euphros. Is this possible, *Cleonicus*?—This will be charming indeed. This will be doing great Things, sure enough.

Cleon. You will soon be satisfied it is possible, by means of this Machine you see here, which is contrived for this very Purpose; for by it you will see both the *Ptolomaic* and *Copernican System* represented, and by comparing the Appearances in each of these with those of the Heavens, you will observe such a palpable Absurdity and Repugnance in the one, and such a perfect Consistency and Agreement in the other, as will leave no Room for the least Doubt, that one is *spurious and false*, and the other the *genuine and true System* of the *World*.

Euphros. Very good, my *Cleonicus*; out, pray, what do you call this curious Instrument, by the Way?

Cleon. It is called a *PLANETARIUM*; because it exhibits a just View of the *planetary System*, at least what relates to the Number, Order, and annual Motions of the primary Planets, all in the same Periods of Time as in the Heavens; for the *Wheel-work* is calculated to a *Minute of Time*.

Euphros. Very good, *Cleonicus*; I see the small Globe of the Earth in the Center, and about it five round, Ivory Balls, which, I suppose, represent the *five Planets*; and a little *Brass Ball* for the Sun, in the third Place from the Center; am I right, *Cleonicus*?

Cleon. You have a very just Notion of the Thing; you are perfectly right, Sister. You farther observe, two Circles on the Surface of the Machine, one containing the 12 Signs of the Ecliptic, and the other the Calender of the Months and Days adapted to it, so that any Planet may be placed in that Part of the Ecliptic, or rather Zodiac, which it possesses for any Day of the Year, and so the whole System may be adjusted for any given Time.

Euphros. Well; and so, by winding up the Machine, you put all the Planets, together with the Sun, in Motion about the central Earth, and thus you represent to me *Ptolomy's System*.

Cleon. I do;—and now you see them all in Motion.—And the first Thing you see is an Argument which proves this System false, and that is,—that the two Planets next the Earth, *Mercury* and *Venus*, can never be seen beyond the Sun in this System.

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Euphros. I plainly see it is impossible ; because their Orbits are both contained within the Orbit of the Sun. But are they seen at any Time to go beyond the Sun, *Cleonicus*?

Cleon. Yes, just as often as on this Side of it ; as we shall have an Opportunity of observing soon.

Euphros. Such an Appearance will give me great Pleasure, and be an undeniable Argument of the Falsity of this System.

Cleon. But you will find a second Proof of the same Thing more flagrant, if possible, than the first.—For you see the Sun, there, in the *West*, Sister ;—and if you look here, you will see the Planet *Mercury* in the *East*.—And, again, there you see the Planet *Venus* in the *South*.—Now these are such Aspects and Positions of the Planets as never were seen by any Man.

Euphros. If I take this Affair right, you mean to shew me, that if this were the true System, I might see (just after *Sun-set*, in a clear Evening) the Planets *Mercury* and *Venus* at any Distance from the Sun from *West* to *East*, don't you, *Cleonicus*?

Cleon. That is the very Thing intended, my *Euphrosyne* ; but you will easily recollect, that instead of seeing these Planets in every Part of the Heavens in a Star-light Evening, you seldom see them at all ; nay, one of them, *Mercury*, so seldom, that you never yet observed it in the least ; and the other, *Venus*, or the *Evening-star*, appears very rarely, being always near the Sun, and when farthest, not more than about 47° , that is, you never saw the said Planet farther from the *Setting-sun* than about *South-west* ; you never saw it in the *South*, or *Eastern* Parts of the Hemisphere of an Evening, which Phenomenon does therefore incontestably prove the Absurdity of this System.

Euphros. I am convinced of it thoroughly ; I do not know that ever I saw the Planet *Mercury* ; and as to *Venus*, I never saw her but in the Circumstances you mention. But what is your next Argument against this *Hypothesis*?

Cleon. The Earth being supposed the Center, the Planets will be in every Part of their Orbits at an equal Distance, and therefore will appear equally big at all Times ; but this is contrary to all Appearances ; for the apparent Magnitude of all the Planets is constantly variable : Nay, so great is the Difference in *Mars*, that at one Time he appears as large as *Jupiter*, and at another Time

and LADY'S PHILOSOPHY. 19

Time so small, that you cannot distinguish him from a *fixed Star*, but by his red Aspect.

Euphros. If this be the Case, it must certainly be an indisputable Argument against the *vulgar Hypothesis*.

Cleon. You will hereafter be fully satisfied, by your own Experience, that is really the Case; at present, that Planet is not in a Situation to be observed, but he soon will.—I shall mention next another irrefragable Argument to the same Purpose.—You see the Planets in this Machine move with an uniform and equal Velocity in every Part of their Orbits.

Euphros. I do so; they move neither faster nor slower in one Part than another.

Cleon. But this is not the Case of the Planets in the Heavens; for they all appear to move there with very unequal Paces; sometimes they are *very slow* in Motion, sometimes very quick, and sometimes they appear *stationary* for some Time, or without any Motion at all. This you may be as easily convinced of as you can desire, in a few Week's Time in the Planet *Venus*, which is now an Evening-star, and very slow in moving from one fixed Star to another; but some Time hence, you will observe, she has *no Motion* at all for several Days, then after that, you'll see her move very fast back again towards the Sun, and be soon lost in his Blaze. In all which Observations, I shall take particular Care to assist you.

Euphros. I shall be obliged to you, *Cleonicus*; and greatly pleased to observe such curious Appearances of the Planets; especially as they will afford me such ample Conviction of the Falsity of this System, which shews this, and every Planet moving constantly with the same even Pace.

Cleon. There remains yet one more Observation to prove this System a most gross and absurd Hypothesis, and that is—you observe, that a Spectator on the Earth, in the Center, would view all the Planets moving *one and the same Way continually*, or from *West to East*; don't you, my *Euphrosyne*?

Euphros. Yes, I do very plainly; I am certain, from what I now see, that the Planets must necessarily appear to move as they really do, since we are supposed to be in the Center of their Motions.

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Cleon. Very good, Sister; but if we are not in the Center of their Motions, they cannot then be seen to move as they really do; but must of Course appear to move in a different Manner; and accordingly we always observe, that in the Heavens they appear to move sometimes from *West* to *East*, sometimes from *East* to *West*; and sometimes to be *stationary*, and have no Motion at all.

Euphros. I make no Doubt of what you say; but you will readily suppose I am not *Astronomer* enough to have observed so much, *Cleonicus*.

Cleon. If you have not, you easily may, my *Euphrosyne*, at any Time almost; but at present you cannot wish for a better Opportunity; for the Planet *Venus* is now moving very slowly towards the Stars Eastward, therefore, the first Star-light Evening, observe her Distance from the next bright Star on the East, and you will see, in a few Days, that Distance will be diminished by the Planet's Approach to the Star.

Euphros. Well, that I shall soon do, and by that Means know she moves Eastwards. But what is the next Thing to be observed, *Cleonicus*?

Cleon. After you have some Time observed her Motion Eastward, you will find she moves slower, by Degrees, till at last she becomes *stationary*, or without any Motion at all; and this you will perceive by her keeping at the same Distance from a fixed Star for several Days together.

Euphros. Very good, *Cleonicus*, I shall endeavour to do that also; and what remains then?

Cleon. After that, Sister, you will observe that splendid Planet return again towards the *West*, and with a very quick Motion to meet the Sun, which she will soon do; and thus you will observe, that soon after she begins to be *retrograde*, she is lost in the solar Rays; or sets *heliacally*, as we call it. These Things you will find are all easy to be understood with a little Observation and Attention; and will be farther illustrated by Experiment, when I come to explain to you the beautiful Construction of the *Copernican*, or true System of the World, in some of our future Speculations on these Subjects.

Euphros. Well, you can't imagine what Satisfaction and Pleasure it gives me to understand how poor and unworthy an
Hy-

Hypothesis that of *Ptolomy* is; how very erroneous, gross, and fallacious the Principles on which it depends; and how many, easy, and convincing Arguments we are supplied with, by Nature and common Sense, to confute it.

Cleon. And, of Course, it must now appear wonderful to you, that there should be so many Retainers to, and strenuous Defenders of this absurd System. But what can be said of invincible Ignorance? It is to no Purpose to urge the Force of *Sense* or *Reason*, nor even of *Truth* or *Demonstration* against it. And therefore we must leave them to the Dominion of Error, and study only the Instruction of the happy few that are capable of Reason and Conviction.*

DIALOGUE V.

A Brief Account of the SOLAR SYSTEM.

Euphrosyne.

THE Morning having been advantageously spent in a Refutation of the *false System*; you are now, *Cleonicus*, indebted to me a few Hours this Afternoon, for an Explanation of the true System of the World, according to your Promise.

Cleon. My Promise shall be always sacred, my *Euphrosyne*, and with the greatest Pleasure I shall now explain to you what is the true State of Nature, with regard to the *Mundane System* of planetary and cometary Worlds; which has been sometimes called the *Pythagorean*, sometimes the *Copernican*, now the *Newtonian*, and then the *Solar System*.

Euphros. Pray, why was it called the *Pythagorean System*, *Cleonicus*?

Cleon. Because, anciently invented and taught by that famous Grecian Sage, *Pythagoras*, and continued so to be by his Followers; but

* The several Phenomena of the *Ptolomaic System*, considered in this Dialogue, will evidently appear, if the Reader has his Eye upon the Diagram in the first Plate (*viz.* Fig. 1.) where the Earth, the Sun, and Planets are so placed, as to represent them separately and distinctly to the View.

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but being lost, in the Ignorance and Barbarity of succeeding Ages, it was again retrieved, and maintained by *Copernicus*, about 200 Years ago; and for that Reason was called by his Name.

Euphros. And because they placed the *Sun* in the Center, it was from thence called the *Solar System*, I suppose.

Cleon. You are right, Sister; and the Appellation of *Newtonian* was given it from its being demonstrated in every Part by that Prince of Philosophers, Sir *Isaac Newton*, who first discovered the Powers employed by Nature; and by observing the Phenomena, explained and established by that unerring Rule, all its Laws of Motion. Thus again Sir *Richard*:

*The Masters form'd in Newton's famous School,
Who does the Chief in modern Science rule,
Erect their Schemes by mathematic Laws,
And solve Appearances with just Applause.*

Euphros. Very *a-propos*, my *Cleonicus*; I find you are a *Newtonian* every Inch of you,

Cleon. Yes, and I expect to see you proselyted to this, not more modish than true Philosophy, before we leave the Subject. I can tell you, Sir *Isaac* has no small Party among the Principal of the *Fair Sex*.

Euphros. I'm glad to hear it; I shall readily make one of the Number, if his Philosophy be the best; but I beg leave first to understand it, if I can, *Cleonicus*.

Cleon. Your Request is very rational; one Profelyte of the Understanding is worth twenty of meer Faith in Philosophy. I shall endeavour to give you a just Idea thereof, and its several Parts, by a Scheme which I have drawn up for that Purpose, and which is nearly a true Representation of the *Solar System*, in which you see the *Sun* possesses nearly the central Point, for Reasons we shall hereafter mention. By the *central Force*, or Power of Gravity, in the *Sun*, compounded with a projectile Force, there are found to revolve the *six Planets* following, *viz.* the first, or nearest Planet to the *Sun* is *Mercury* ☿; the next is *Venus* ♀; the third is the *Earth*, with her *Moon*; the fourth is *Mars* ♂; the fifth *Jupiter* ♃; the sixth and last is *Saturn* ♄; these all move about the central *Sun* in different Spaces or Periods

COPERNICAN or SOLAR SYSTEM;

Shewing the Number, Order, Distances, and Magnitudes of the
PRIMARY PLANETS in proportion to that of the SUN,

which is represented by the Sphere of Saturn.

Plate III

Saturn



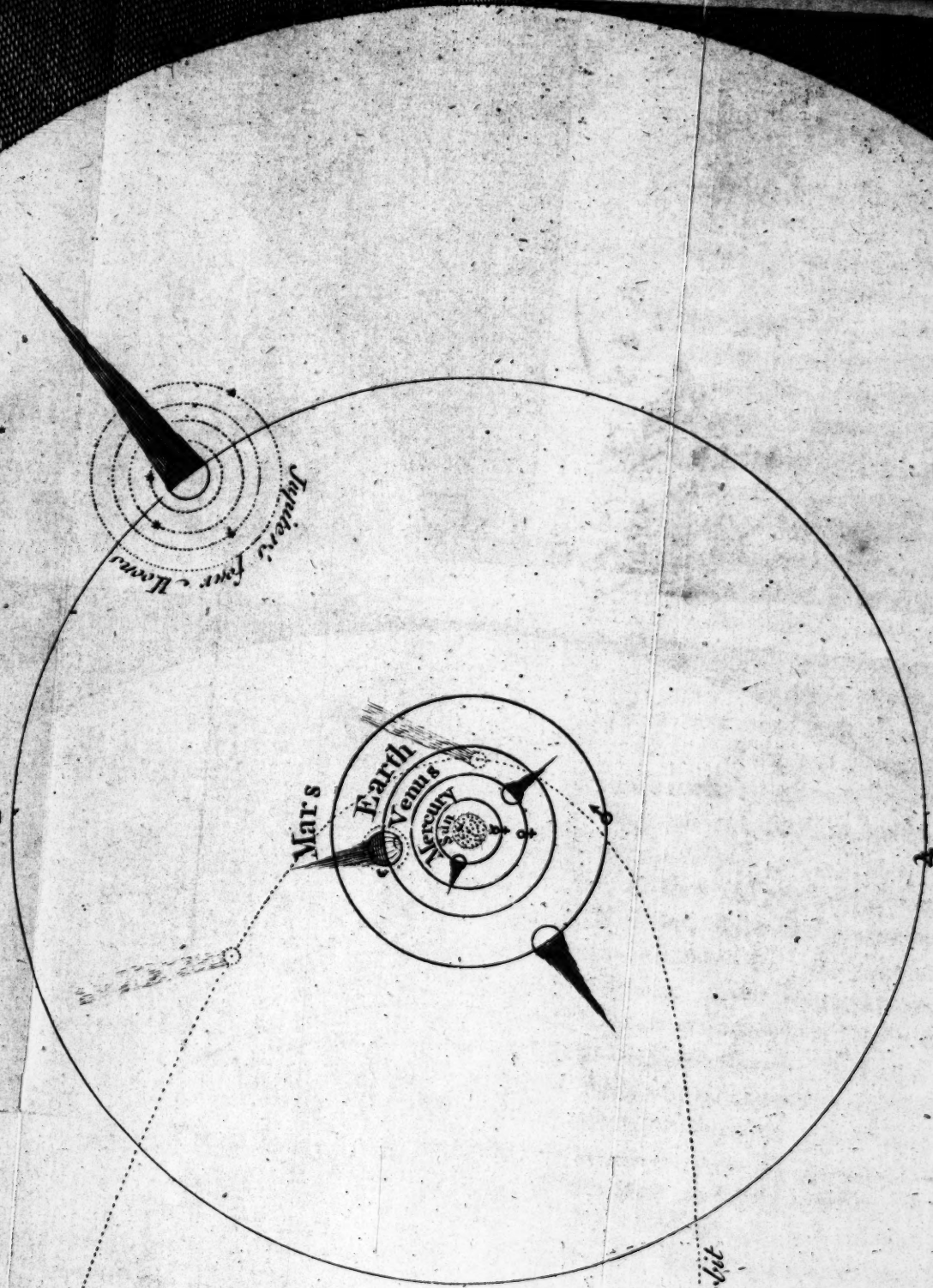
Equator of Saturn

Mass the Earth Times Mercury



Saturn and his Double Ring

Jupiter



Part of a Comet's Orbit

Saturn's Five Moons

Periods of Time, and in Orbits that are very nearly circular, or such as represented in this Scheme.

Euphros. I observe you have made the Orbs of the Planets circular, but the Orbit of a Comet, I see, you have represented as Part of a very long Oval: Do all the Comets go round the Sun in such oval Figures?

Cleon. Yes, my *Euphrosyne*, they all move in Orbits, which are more or less oval, or (as the Astronomers call it) *Elliptical*; for what you call an *oval Figure*, they always call an *Ellipsis*.

Euphros. The Learned, 'tis fit, should be allow'd to speak in a Phrase above what is vulgar; but I take it then only as uncivil or ungenteel Usage, when they amuse us with unintelligible Terms; since we ought always to understand what is offer'd us to read. But this by the Way; pray *Cleonicus*, what do you intend by those small Stars round *Jupiter* and *Saturn*, in the Scheme?

Cleon. They are little Moons, which the Astronomers call *Satellites*; these light those distant Planets thro' their dreary Way; while others which are nearer the Sun, and have therefore a greater Degree of Light, have none of them, save our Earth only, which has but one.

Euphros. These, I presume, are all the great Bodies which compose our System, because I see no more in the Scheme; but pray, what have you done with all the Stars? Do none of them fall to the Share of our World?

Cleon. They are all at a vast Distance from our System, and make no Part of it; as you will see hereafter. You will cast your Eye on the Diagram once more, and observe, that the Bulks, or Magnitudes of the Sun and Planets are there also represented.

Euphros. I see it, I believe; does not the Orb of *Saturn* represent the Face of the Sun, and the several other white Globes the comparative Bigness of the Planets whose Names they bear?

Cleon. Yes, my *Euphrosyne*, they do; they are here drawn in Proportion to the Sun, of more than eight Inches in Diameter, and from thence you observe how small a Figure even the largest of them all makes in Comparison of that glorious, central, solar Globe.

Euphros. Small indeed! I am almost ashamed for our Earth; really 'tis scarce visible in the System. Heavens! what a Bustle
do

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do we Mortals, make about this Globe of Earth, when we see and consider it alone; but how little a Thing does an Empire or Kingdom, nay, the Earth itself appear, compar'd with the whole System.

Cleon. What you observe, my *Euphrosyne*, is very just; we learn by such Reflections one useful Lesson, that Things are great and small only by Comparison; in regard to many other Properties of Bodies, you will find that this Doctrine will also hold good, as we proceed in our Speculations.

Euphros. I suppose, the Distances of the Planets represented in the Print, are in Proportion to those in the Heavens, are they not, *Cleonicus*?

Cleon. They are so, as nearly as those Distances are at present known; but in the Year 1761, when *Venus* will appear on the Sun's Face, the Distances of the Sun and Planets will be very accurately determined, and not till then. We shall therefore conclude with a View of this System in Sir *Richard's* poetical Description.

*This wide Machine the Universe regard,
With how much Skill is each Apartment rear'd;
The SUN, a Globe of Fire, a glowing Mass,
Hotter than melting Flint, or fluid Glass;
Of this our System holds the middle Place.
MERCURIUS nearest to the central Sun
Does in an oval Orbit circling run;
But rarely is the Object of our Sight:
In solar Glory sunk, and more prevailing Light.
VENUS the next, whose lovely Beams adorn,
As well the dewy Eve as opening Morn,
Does her fair Orb in beauteous Order run.
The GLOBE TERRESTRIAL next, with slanting Poles,
And all its pond'rous Load unwearied rolls.
Then we behold bright planetary JOVE,
Sublime in Air thro' his wide Province move.
Four Second Planets his Dominion own,
And round him turn as round the Earth the Moon.
SATURN revolving in the highest Sphere
With ling'ring Labour finishes his Year.*

DIALOGUE

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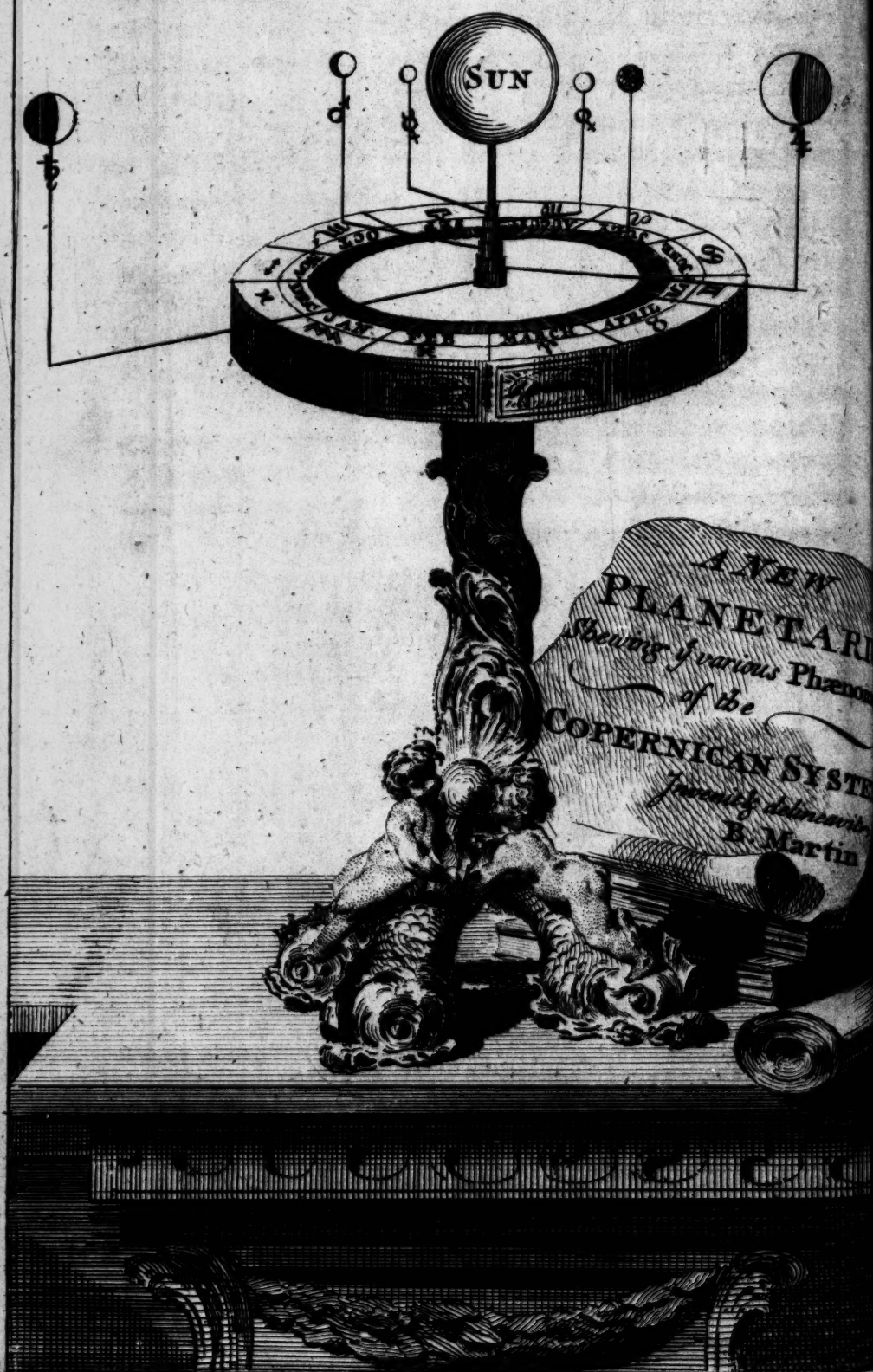
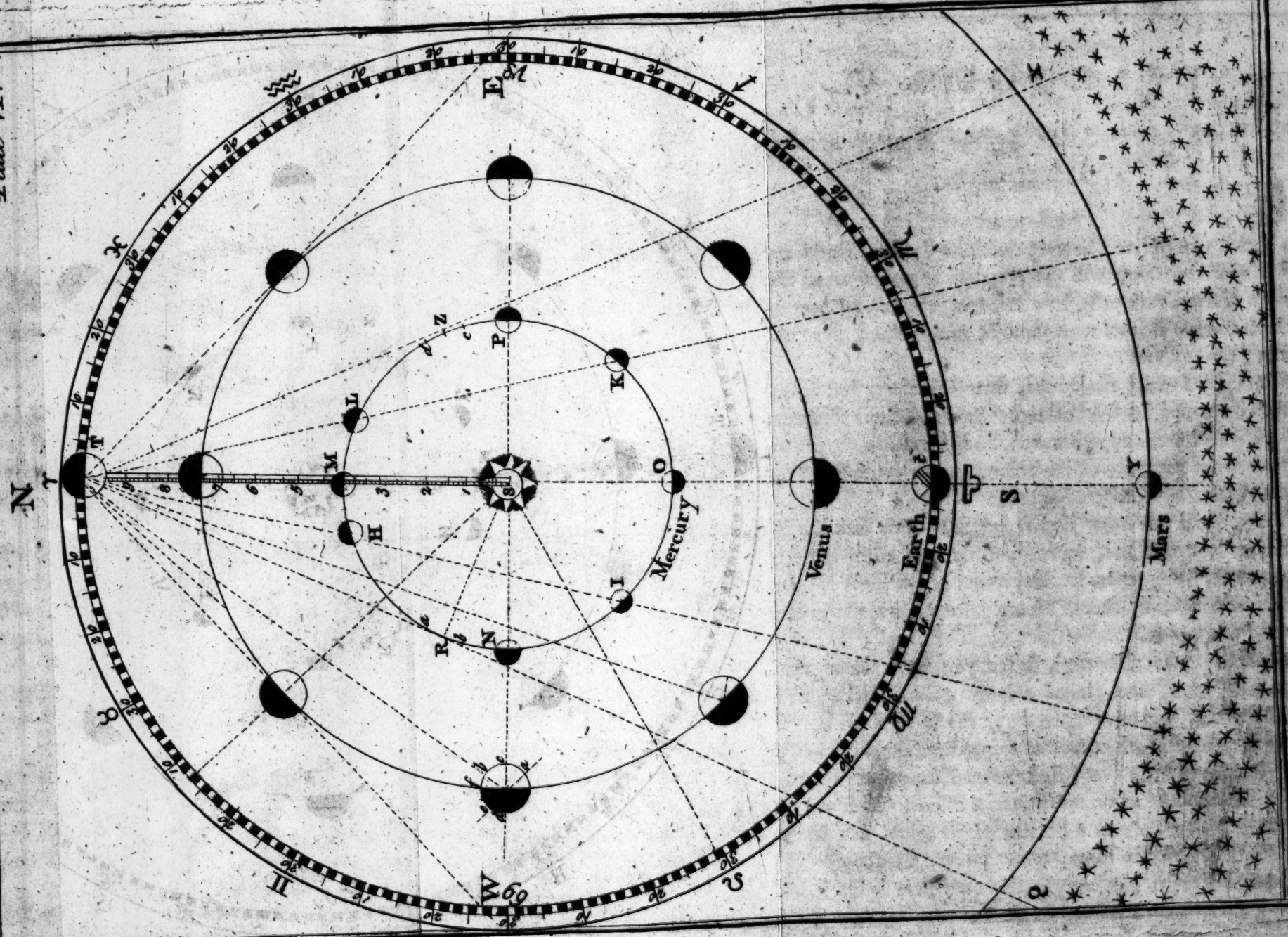


Plate VI.



DIALOGUE VI.

The Truth of the Solar System demonstrated by the Planetarium.

Cleonicus.

BY this descriptive View of the Solar System, I presume, my *Euphrosyne*, you will be prepared to understand a Demonstration of the Truth of it, by comparing the several Appearances of the heavenly Bodies with those of this System, as represented by the *Planetarium*.

Euphros. I make no Doubt, dear *Cleonicus*, but I shall, as you have a happy Method of representing Things so natural and easy; especially as I apprehend the Subject now is but just the Reverse of what you shewed me before, when you refuted the *Ptolemaic System*, by the same Machine.

Cleon. It is true, my *Euphrosyne*, Truth is but the Reverse of Error, at any Time, and to be convinced of the latter is more than half the Way towards a Discovery of the former. In order to this you observe, there is some Alteration made in the Face of the *Planetarium*.

Euphros. I do, *Cleonicus*, I see you have taken the Earth from the Center, and placed a large golden Ball in its Stead; also I observe, you have taken away the small Brass Ball from among the Planets (which before represented the Sun) and placed, in its Room, a little Ivory Ball, with Circles, to represent our Earth, I suppose, as no more than a *Planet*; these are bold Innovations, *Cleonicus*, in a System of Worlds; but I know you are able to answer for them, when there is Occasion.

Cleon. Yes; while we are able to give a good Reason for what we do, we are always secure and courageous; 'tis a prodigious Advantage to have *Nature* and *Truth* both on our Side; one supplies us with all the Powers of *Logic* and *Rhetoric*; and the other renders us always victorious and triumphant. This has been, and ever will be the Case of the *Solar-System*, and all

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other

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other Parts of the *Newtonian Philosophy*, since they have been considered and treated in a proper Manner.

Euphros. Well, *Cleonicus*, I find you are a Champion in the Cause of Philosophy; but put the Machine, if you please, into Motion, and let us proceed to Particulars; for I long to be instructed in this most beautiful Part of the Science.

Cleon. I will. — I wind up the Spring, and — you see all the Planets in Motion, at the different Distances, and Degrees of Velocity.

Euphros. I do, *Cleonicus*, with Abundance of Pleasure; and I suppose, by this Means, I have now a proper Idea of the true System of the World; or is there any Thing yet wanting?

Cleon. Yes, my *Euphrosyne*, too much is yet wanting to compleat a perfect Idea of the System, at least, in one View — Nor is it in the Power of Art to supply every Thing. The proportionable Distances of the Planets, together with the true Proportion of their Magnitudes, can never be shewn in any Machine, but separately they may; as you have already observed in the Plate of the Solar System. And I shall only here observe, that if the Magnitudes are the same as there represented, the Distances of the Earth from the Sun would be 83 Feet, and that of *Saturn* nearly 800, so that the Orbit of *Saturn* would be almost a *Mile* in Circumference, and consequently no *Planetarium* can ever be made to express the Proportion of Distances and Magnitudes at the same Time.

Euphros. I am convinced it cannot be done, *Cleonicus*, by what you have said; and one Thing I observe farther, and that is, it would be but of little Use if it could be made so large; since then we must be at the Trouble of walking from one Part to another to view the several Bodies of the System; for it is easy to see, that *Mercury*, *Venus*, the *Earth*, and *Mars*, would be all of them by much too small to be seen at the Distance of *Saturn*, (and indeed the three first at *Jupiter*) without a Telescope. I protest, *Cleonicus*, I can scarce reflect on such diminutive Considerations of the Earth, without feeling some Uneasiness; I am quite concerned, when I think what a mean, and almost pitiful Figure we make in the System. However, there is one Comfort; we are not the least of all the Planets.

Cleon.

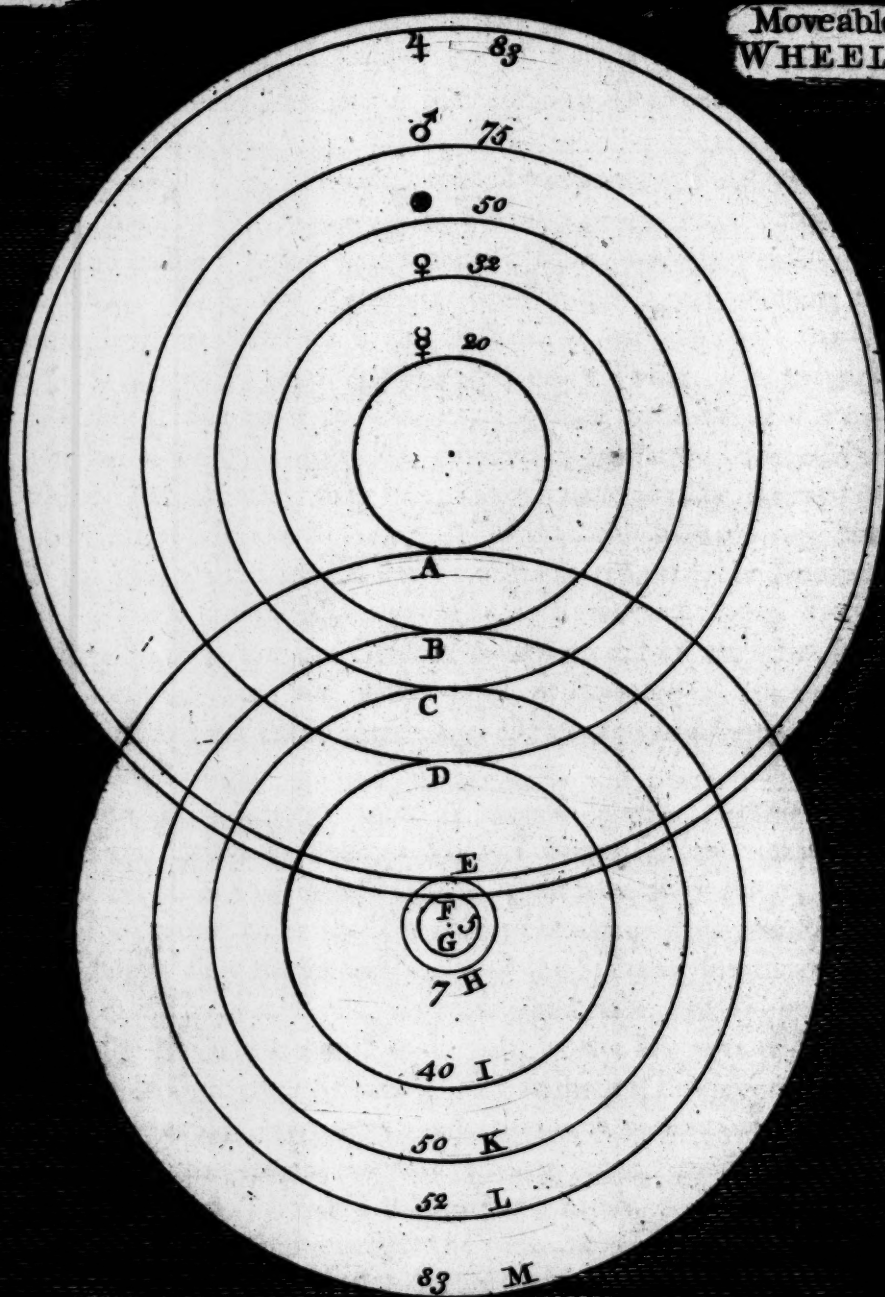
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A View of the WHEEL WORK of the PLANETARIUM

Plate VI

Moveable
WHEELS



WHEELS Fixed on an ARBOR

Cleon. No, no, Sister, don't be discouraged; our Earth is a Planet of the *third Magnitude*, if that will afford you any Consolation. — But let us attend to the Machine; you there observe one Thing right, *viz.* the Velocity of the Motion of the Planets, and consequently, the Planets here finish their Periods sooner or later, just as they do in the Heavens. And not only this, but every other *Phænomenon* is the same here as you observe it in Nature, as will be evident by considering them severally, as we did when the *Ptolomaic System* was represented, and confuted by it.

Euphros. This I shall attend to with great Pleasure; for it is still a superior Satisfaction to see what Truth is, and the Ways and Means by which it is infallibly discovered; as our little mundane System, therefore, is all in Motion, pray, *Cleonicus*, proceed to Particulars.

Cleon. I will, my *Euphrosyne*, and begin with the *Phænomena* of *Mercury* and *Venus*, as before; only here you are supposed to be a Spectator of these Motions, from that small Globe with Circles that represents the Earth; and from thence you see those two Planets in one Part of their Orbits pass before the Sun, and, in the other Part, behind, or beyond it; and this is their constant Appearance in the Heavens.*

Euphros. I see it must necessarily be so; and it is surprizing to me, that so very plain a Case was not alone sufficient to convince Mankind in every Age of the Truth of this System.

Cleon. The longer you live, the less you will be surprized at such Things; you will find Ignorance, Prejudice, Party or Policy, always eclipsing the Truth, as Clouds do the Sun, tho' both are in themselves the brightest Objects in Nature. You will find, the next *Phænomenon* you observe is equally coercive, if Men would reflect or attend to it at all, *viz.* that *Mercury* and *Venus*, can never appear to us at any great Distance from the Sun; *Mercury* not above 21 Degrees, and *Venus* not more

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than

* The Reader is here supposed to have his Eye upon the Diagram in Plate V. where all the *Phænomena*, mentioned in this Dialogue, are represented just as they are seen in the *Planetarium*. Thus, *Phænomenon* I. to an Eye placed on the Earth at T, the Planet *Mercury* at M, and *Venus* at V, will appear to pass before the Sun; and at O and D they are beyond, or behind the Sun, if viewed from the same Place.

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than 47; and this corresponds exactly with the Distances from the Sun in the Heavens when greatest of all.†

Euphros. I have hardly Geometry enough to understand Measuring Distances by Degrees; but, I easily see the Thing you drive at, and indeed you have already explained it to me in a former Conversation.

Cleon. You will find, my *Euphrosyne*, that a very little Mathematics is requisite for understanding the Phænomena, when we come to explain it still farther by a proper Diagram, exhibiting the Theories of these two Planets; and a particular Piece of Machinery added to the Orrery for that Purpose: The next Phænomenon will create you no Difficulty; for as you observe, the Distance of the Earth is perpetually altering, with respect to any Planet, I suppose, you have Philosophy enough to see what will follow from thence.*

Euphros. Very plainly, *Cleonicus*; I have, 'tis to be hoped, common Sense enough to know, that when the Earth is near to any Planet,—that Planet will appear larger than it will do when the Earth is remote from it, and thence I may infer, that the apparent Magnitudes of the Planets are always variable; and so, I suppose, you observe them to be in the Heavens; for I remember well what you said of the Planet *Mars*, when we considered this Phænomenon in *Ptolomy's* System.

Cleon. I am glad to find you can so happily recollect, and compare these Appearances. We have, from the same Principle too, the Solution of another common Phænomenon of the Planets; pray do you remember that also?

Euphros.

† Phænomenon II. If right Lines be drawn from the Earth at T, touching the Orbits of *Mercury* and *Venus*, in the Points R and A, on one Side, and Z and G on the other, 'tis evident those Lines will be farther from the Sun, than Lines drawn to any other Points of those Orbits, and consequently, the Planets, in those Points, will be seen farther from the Sun than in any other; and the Angle S T R will be found about 21 Degrees, and the Angle S T A about 47.

* Phænomenon III. 'Tis evident, that as the Planet *Mercury* moves from M to H N T; and *Venus* from V to A B C they will appear less and less; and that their apparent Magnitudes will encrease as they move from O to K P I, and from D to E F G towards the Earth at T, also since the Earth at T is about 5 Times farther from *Mars* at Y, than it is when at T, the said Planet will appear 25 Times less in the Former than in the latter Situation.

Euphros. I believe I do; for my Reason suggests to me, that the apparent Motions of Bodies must be greater when they are near, than when they are very far off; and moreover, that their visible Magnitudes and Motions are always greatest and least at the same Time *.

Cleon. Very good, my *Euphrosyne*; there is some Pleasure in teaching Philosophy to you, who will soon be Mistress of many of the most useful Doctrines of the Science; you already know the Reason why the Planets apparent Motions must be very unequal; but why they should sometimes appear stationary, or without any Motion for a Time, I do not expect you to apprehend so readily as yet; but hereafter you will see no Difficulty in that.

Euphros. I perceive Science is a gradual Thing, *Cleonicus*; nor do I expect to be wise all at once: I shall be very well satisfied, if with Time, I can acquire such a Competency of Knowledge as is fit for a *Woman*.

Cleon. You should say, a *reasonable Being*, my *Euphrosyne*; useful Science is of neither *Sex*, or any Party.——But to return.——While the Planets are in Motion, you observe, from the Earth they will be seen to move in *different Directions*; for Instance, *Mercury* you see is now on the *Left-Hand* side, or *East*, of the Sun; but from thence he moves on this Side of the Sun to the West;——from that Western Situation on the Right-Hand, he moves on behind the Sun to the East Side, where he was before; so that in one Revolution, he is seen to move from *East* to *West*, and from *West* to *East* †.

Euphros.

* Phænomenon IV. In the Points of the Orbits where the Planets are nearest, as at V and M, they will appear to move *fastest*; and *vice versa*, at the remotest Points O and D; also the Velocity of the Planet *Mars* at Y, will appear = 5 Times greater to the Earth at t, than it will do when the Earth is at T, at 5 Times the Distance as before.

† Phænomenon V. It is easy to observe in the Scheme, that to an Eye placed at T, the Planet *Mercury*, as it passes from R, by O, to Z, will appear to move forwards, according to the Order of the Signs, or from West to East; but from Z, by M to R, it will appear to move the contrary Way, *viz.* from East to West, or be retrograde. And a little Way on each Side the Points R and Z, *viz.* from A to B, and from C to D, the Planet must appear stationary, or at Rest among

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Euphros. I see it clearly, *Cleonicus*, and I remember also, you observed to me (in the other System) that this is the Case of all the Planets; and I expect I shall be able to see it verified by my own actual Observations on the Planet *Venus*, in a little Time, after the Manner you then directed me.

Cleon. You will then commence a *Practical Astronomer*, Sister; and indeed by a little Attention and Practice, you will find it not only easy, but pleasant to observe all the Phænomena of the Heavenly Bodies to be the very same as you have seen in this *Planetarium*; and then you will be fully convinced of the Truth of this System.

Euphros. I shall, nay, I am so already, *Cleonicus*; for I think it is impossible any one, who has seen all those Things so naturally, and, as it were, doubly represented, as I have, should not be convinced, at least, that the Earth is a Planet, and the Third from the Sun;——But pray, *Cleonicus*, may not these Appearances happen to a Spectator on the Earth at Rest among the Planets, as well as on the Supposition of its Motion; if so, there will still lie an Objection against the Earth's Motion.

Cleon. 'Tis with great Pleasure I hear you make this Question, as you thereby discover almost a critical Sagacity in these Matters in so short a Time. I answer, my *Euphrosyne*, the Phænomena, 'tis true, would be the same to the Earth at Rest, as we have now specified them; but you must know withal, that they would not, in that Case, happen at the same Times they now do, nor in the same Parts of the Heavens.

Euphros. I am very desirous of seeing this illustrated, *Cleonicus*: Can you shew it in the *Planetarium*?

Cleon. Very easily; for I'll fix the Earth at Rest in the Beginning of the Ecliptic, or first Point of *Aries* (as it is no Matter where) and bring the Planet *Mercury* in a right Line with the Earth and Sun; it is then in Conjunction with the Sun; then, putting the Machine in Motion, you observe that Planet, in 88 Days, comes to the same Place again, and therefore, if the Earth were at Rest, the Time between two Conjunctions of the same Kind, would be just equal to the Period of the Planet's Revolution,

among the Stars at Q and X, since those small Parts of the Orbit do nearly coincide with the Tangent Line. But this Matter will be farther explained in a future Dialogue.

Revolution, and always in the same Point of the Ecliptic:
Do you understand me? *

Euphros. I must be very dull indeed, if I did not perfectly well——

Cleon. Then —— I put the Earth, as usual, in Motion; setting out with the Planet; —— but you see, when *Mercury* returns to the same Point again, the Earth is gone, and the Planet keeps moving on 'till it overtakes the Earth. — Here you observe a Time considerably longer than the Period is taken up between the two Conjunctions, *viz.* more than 110 Days.

Euphros. I see wonderfully plain, and also I observe the Earth has passed over about a third Part of its Orbit in the Time; and consequently, I must needs know, that both the Time and Place of the present Conjunction are very different from the former; and therefore am necessarily convinced of the Motion of the Earth, as well as of all the rest of the Planets about the Sun. I see the Truth, and much of the Beauty and Harmony of the Solar System; for which I shall be ever infinitely indebted to my dear *Cleonicus*.

Cleon. They who contemplate Nature, my *Euphrosyne*, always find their Admiration and Pleasure encreasing with their Knowledge; the more nearly we view her, the more engaging she appears; and what you have yet seen is but, as it were, an *Antepast* of the sublime Consolations of Philosophy, that will most certainly reward your future Enquiries, as you will acknowledge, when you come to understand the Doctrine of *Eclipses*, and to be able to calculate one.

Euphros. To calculate an Eclipse! A strange Thing to talk of for a *Woman*, *Cleonicus*.

Cleon. A Woman! —— Why, this *Woman-hood* of yours, seems to be mightily in the Way. —— I must tell you once more, my *Euphrosyne*, that it is at present quite out of the Question; for if indulgent Heaven has favoured you with such mental

* Phænomenon VI. In the Diagram, it is evident, if the Planet *Mercury* be in Conjunction at M, and the Earth at Rest at T, it will be in Conjunction again, after one Revolution, in the same Point M, *viz.* in 88 Days. But supposing the Earth and Planet go on together from the Points T and M, the Planet will have made one Revolution, and Part of another, before it can get between the Earth and Sun; it will then be nearly in the Point Q and the Earth will be in $\ominus$, about four Signs distant from T, the Place of the former Conjunction.

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tal Faculties and Powers as will enable you to understand these Things, then why may you not with as good a Grace, and to as great an Advantage, address yourself to such an Undertaking? I know some Ladies, and doubt not but there are many others, who can calculate both a Solar and Lunar Eclipse, and intend my *Euphrosyne* shall not be behind-hand with any of them. Nay, farther, I have a Sort of easy *Philosophical Geometry* too, nicely adapted to the Genius of the *Fair Sex*, which will let you into the *Rationale*, or Reason of every Step you take in such a Process.

Euphros. You have said enough, *Cleonicus*; if you enlarge much farther, you will surely make an *Angel* of me.

Cleon. There is no Need of that, in the Judgment of some People that you know in the World.

Euphros. Prithce hold thy Tongue, *Cleonicus*;—and tell me what is in the Inside of this Machine of yours: Is there any Thing that I can understand by what Means you make Art and Nature so wonderfully agree?

Cleon. Yes, surely, and nothing shall be denied to the Curiosity of my *Euphrosyne*; I will take off the Top of the Machine,—and there you observe several Parcels of Wheel-work, great, and small.—Of the first, you see six Wheels all fixed on one Arbor.—

Euphros. I do, *Cleonicus*, and as they differ in Size, so I observe they do in Number of Teeth, which I suppose are shewn by the Figures stamped on each Wheel.

Cleon. You are right, Sister, and you farther observe, the Teeth of these fixed Wheels play in the Teeth of six other moveable Wheels, all placed about one common Axle.—In each of these Wheels, there is fixed a long Pipe, or Socket, on the Top of which each Planet was fixed, as you saw on the Out-side of the Machine.—

Euphros. You need say no more, *Cleonicus*, for I observe now how the Planets are made to move in general; for when the Set of fixed Wheels are put into Motion, the other Wheels are severally moved round in different Times, I see, by the different Number of Teeth in each.—

Cleon. Very well, my *Euphrosyne*, and in each Set you observe the *third Wheel* from the Bottom is the same, and has the

same Number of Teeth, consequently they go both once round in the same Time; therefore may represent our Year; for you see the Ball which represents our Earth is carried round on the Socket of that Wheel.

Euphros. All this I see very plainly; and how then, *Cleonicus*?

Cleon. Then by the Proportion of the other Wheels, the other Planets are made to revolve in their proper Periods of Time. Thus, the first Wheel of 83 Teeth drives the first of the other Set of 20; therefore *Mercury*, on its Socket, must move a little more than four Times round, while the Earth moves once round; for the Number of Teeth in the two Wheels will always be as the Number of Days in the Earth and Planets Revolutions, that is, 83 is to 20, as 365 to 88 nearly; and therefore in 88 Days, the Planet will make one Revolution about the Sun. I hope you understand me, Sister?

Euphros. I do very well, *Cleonicus*; and for the same Reason, I see the Period of *Venus* is to the Length of our Year, as 32 to 52; in *Mars*, as 75 to 40; in *Jupiter*, as 83 to 7; and in *Saturn*, as 148 to 5. I see the Reason of this Affair with much more Ease than I imagined I should.

Cleon. Every Thing, my *Euphrosyne*, will be tolerably easy, when it is well represented, and rightly considered; the Rationale of Things is not so very mysterious in such Cases, as is generally thought. — In the Barrel, you see there is a Spring, which by Means of the Fusee, and its Wheels, puts the Work into Motion; as in a common *Watch*, or *Spring-Clock*, and the Motion made equable by a Regulator: So much at present for the Mechanism of the *Planetarium*. We shall entertain ourselves with a more immediate View of the great Bodies of the System, as we have Opportunity; and the next fair Evening, I will shew you the Face of the Sun thro' a *Telescope*, when he is near setting, for then we have the most advantageous View of that glorious Lamp of Day.*

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* The Reader will observe in Plate VI. that the

Moveable Wheel.

Fixed Wheel.

A ☿ of 20 Teeth

B ♀ of 32

C ⊖ of 50

} is driven by { A M of 83 Teeth.
B I of 52
C K of 50

D ☿

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Moveable Wheel.

D ♂ of 75 Teeth

E ♀ of 83

F ♀ of 148

Fixed Wheel.

} is { D I of 40 Teeth.

} driven { E H of 7

} by { F G of 5

Hence, if the Time of one Revolution of the Wheel C ⊙, which carries the Earth, be divided into $365\frac{1}{4}$ equal Parts, or Days; therefore, since all the fixed Wheels make one Revolution in the same Time, it follows,

That $83 : 20 :: 365\frac{1}{4} : 87\frac{3}{4} = \text{♀'s Period.}$

$52 : 32 :: 365\frac{1}{4} : 224\frac{2}{3} = \text{♀'s Period.}$

$40 : 75 :: 365\frac{1}{4} : 687 = \text{♂'s Period.}$

$7 : 83 :: 365\frac{1}{4} : 4332\frac{1}{2} = \text{♀'s Period.}$

$5 : 148 :: 365\frac{1}{4} : 10759\frac{1}{4} = \text{♀'s Period.}$

From whence it appears how very accurately the *Annual Motions* of the Planets are determined by this Machinery.

DIALOGUE VII.

Of the SUN.

Cleonicus.

COME forth, my *Euphrosyne*, and let us walk to yonder little Hill, on the Summit of which, we shall have a delightful and inoffensive Prospect of the milder Sun in his Decline; and the Sky being serene, and free from Clouds, we shall see him gradually make his Exit out of our Hemisphere to that below.

Euphros. That to me will be a grateful Sight, my *Cleonicus*; and I remember, in our last Conversation, you proposed to contemplate the Nature of the Sun more immediately, when we should next walk together.

Cleon. Yes, I did so; and, as if apprized of our Design, he seems to offer himself for the Subject of our Speculation this fair Evening. His Face looks of an inviting Aspect, large, red, and gently glowing; which reminds me of the Poet's Description:

*The Disk of Phœbus, when he climbs on high,
Appears at first but as a blood-shot Eye,
And when his Chariot downwards drives to Bed,
His Ball is with the same Suffusion red;
But mounted high on his meridian Race,
All bright he shines, and with a better Face.* Dryden's Ovid.

Euphros.

and LADY'S PHILOSOPHY. 35

Euphros. Well, the Sun, to be sure, is a noble Subject of Poetry, as well as Philosophy! But, pray, *Cleonicus*, can you tell me any Thing of the Original of the Sun, and of what his wonderous Body is compos'd?

Cleon. Very little can be said on that Head; *Moses*, you know, informs us, that God, at the Creation, first called for *Light*, and then he made the *Sun*; and 'tis generally supposed, he made the huge Body of the Sun a Kind of Receptacle, or Reservoir of Light, from whence it might be dispersed thro' all Parts of the System; and thus the famous *Milton* has paraphras'd it in these excellent Lines:

*Then of celestial Bodies first the Sun,
A mighty Sphere, he framed; unlightsome first,
Tho' of ethereal Mould: He form'd the Moon
Globose, and every Magnitude of Stars.
Of Light by far the greater Part he took
Transplanted from her clouded Shrine, and plac'd
In the Sun's Orb, made porous to receive,
And drink the liquid Light; firm to retain
Her gather'd Beams: Great Palace now of Light;
Hither, as to their Fountain, other Stars
Repairing in their golden Urns draw Light;
And hence the Morning Planet gilds her Horns.*

Paradise lost.

Euphros. And does not the Light, thus collected, make the Sun's Body a Globe of Fire?

Cleon. Undoubtedly; and the most intense and ardent Heat possible must be there conceived.

Euphros. I imagine so; for I have seen a Book in my Papa's Library, which was wrote to prove, that the Sun was the horrible Place which we call *Hell*.

Cleon. 'Tis certain, the Sun is both large enough, and hot enough; and if it be not there, 'tis hard to say where it should be. 'Tis certain, however, if *Milton* be right, the Devil is no Stranger in the Sun; for in his vagabond Flight thro' our System, he makes him light on the Sun, and compares him to a Spot in his Surface.

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— There lands the Fiend, a Spot like which perhaps
Astronomer in the Sun's lucid Orb,
Thro' his glaz'd optic Tube, yet never saw.

Euphros. This is a Fancy in the Poet pretty enough; and now you talk of Spots in the Sun, pray what, and how many are they? Have you ever seen them, *Cleonicus*?

Cleon. Yes, my *Euphrosyne*, very often; and they make a very odd Figure in the Sun's Face; their Number is very uncertain, being sometimes more, sometimes fewer, and sometimes you will see none at all.

Euphros. How big do they appear?

Cleon. Some are large, and some small; it has been observed, that some have been above 100th Part as wide as the Sun's Face,

Euphros. How do they appear situated there?

Cleon. Sometimes many together in one Part, in another Part you see them single; but they are hardly ever seen twice in the same Form, Magnitude, or Situation.

Euphros. Why then they are continually in Motion, I find; pray, is that Motion any Thing regular?

Cleon. Yes, extremely so at all Times; they move, all of them, from the *Eastern* to the *Western* Limb of the Sun, and that in the Space of 13 Days nearly.

Euphros. When, and by whom were they first discovered?

Cleon. By the famous *Italian* Philosopher *Galileo*, in the Year 1610.

Euphros. What do Philosophers say they are?

Cleon. Why, I can assure you, dear Sister, the *Indian* Kings, when here, were not more puzzled to account for the Nature, Appearance, and Disappearance of the Beauty-spots on the Faces of the *English* Ladies, than the Astronomers are to account for those of the Sun. Some think, they are not in the Body of the Sun, but are some dark Bodies, like Clouds, floating in an Atmosphere about the Sun; and which, when before him, seem like Spots in his Surface. But others more probably suppose, they are really in the Sun, and occasioned by an Eruption of Smoke, and other opacous Matter, in various Parts of his Surface; this, as it gradually spends itself, makes the Spots degenerate into others which look cloudy or misty; and in the last Place,

Place, the said *Calx*, or dark Matter, being quite dissipated, an Eruption of horrid * Flames succeeds, as in a *Volcano*, which make the bright and flaming Parts, that some have observed to come in Place of the Spots. This is the best Account, my *Euphrosyne*, that I can give of the *Solar Spots*.

Euphros. I thank you, Brother; but it would be a greater Gratification to have a Sight of these Spots; could you no how shew them to me?

Cleon. Yes, very easily; and 'tis what I intended, when we came out; for which Purpose, you see, I have brought with me this small Telescope, in which I have put a smoaked Glass next the Eye, that the excessive Brightness of the Sun might not hurt it in viewing him.

Euphros. Dear Brother, I see you are very careful to oblige me in every Thing; but the Sun is almost down, if you be not speedy, we shall lose Sight of him.

Cleon. There is just Time enough; you will now see him also gradually descend the Horizon. Let the Tube be laid upon the upper Bar of this Gate, it will just fit your Eye.

Euphros. It does so indeed. —

Cleon. The Telescope is now right to the Sun; put your Eye to the End.

Euphros. I do. —

Cleon. Can you see any Thing?

Euphros. Yes, the Orb of the Sun, prodigious large and bright. — I see a Cluster of Spots in the upper Part; I think there is about 11 or 12. — I see a very large one on the left Side, — and two more towards the Bottom. — 'Tis an extreme Curiosity, indeed, but it makes my Eye ake. —

Cleon. Rest a little, and then view him as he sets. —

Euphros. I will. — But he seems now to touch the Earth. — I'll view him.

Cleon. He is not so near the Earth in the Glass. —

Euphros.

* The *Feculae*, or flaming Parts of the Sun, we have here mentioned, as they have been described by others, and particularly by Mr. *Derham*; but we must confess, tho' we have more than 30 Years constantly observed the Solar Disk thro' very good Telescopes, we never saw the Appearance of any such Thing.

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Euphros. He's yet a Foot above the Earth: — Now he just touches it; — the two Spots below are just hid; — the large Spot in the middle touches; — is gone; — the Cluster begins to dip; — they are all down; — the Sun is almost gone; — there, he is quite down. — Well, of all things I ever yet saw, this is the most delightful and ravishing Sight! How prodigious large he appears thro' the Glass! Pray, can you tell how big he really is?

Cleon. Not certainly; because his Distance from the Earth is not certainly known; however, 'tis computed, that the Sun is in Diameter above *Eight Hundred Thousand Miles*; and if so, his Bulk will be a *Million of Times* greater than our Earth.

Euphros. Prodigious! I do not wonder you place him in the Center of the System; it would be a monstrous Piece of Contrivance, to make a Body so immensely great as the Sun, move about the Earth, which in regard of him is so very small.

Cleon. You conceive very well of the Matter, Sister; such Conduct, in forming a World, can never be supposed in the all-wise Creator, as would be unsufferable in a common Mechanic. But that the Sun is in the Center of our System you have already seen sufficient Proof.

Euphros. And has the Sun, then, no Motion at all?

Cleon. If the Spots are only Blemishes in the Sun's Face, and are fixed there as Patches on a Lady's Face, 'tis certain, the Sun has a Motion about its own Center, or Axis; and that in about 25 Days 15 Hours. And this is now no longer an Uncertainty, but proved by the constant Uniformity of their Motion.

Euphros. But tho' the Sun may move upon it's Axis, yet I suppose it to be at Rest in the Center of the System, I mean, so as not to move out of it's Place, is it not, *Cleonicus*?

Cleon. No, Sister, not perfectly at Rest there neither. For you must understand, there is a certain Point, which is the *true*, or *common Center* of all the Planetary Motions, and this Point is at most not quite a Diameter of the Sun distant from it's Center; about this Point, therefore, the Sun, as well as all the Planets, move; but in what Time is uncertain.

Euphros. Well, this Evening has been happily spent! And now upon our Return Home, let me know what Kind of poetical

cal Philosophers we have ; for I make no doubt but the Muses sing very harmoniously on such a glorious Subject.

Cleon. Oh, very finely indeed ; the great Works and Scenes of Nature, you'll find, are the most agreeable Themes of the Muses ; they never sing sweeter than when they chant the Wisdom and Magnificence of creating Power. Thus the Rev. Mr. Brown :

*In the Beginning, the Almighty said,
Let there be Light ; that Instant Darkneſs fled ;
All radiant Day her roſy Beams diſplay'd,
And the young World in ſplendid Dreſs array'd.
The blazing Sun, upriſing from the Eaſt,
Like a young Bridegroom in his Glories dreſs'd,
His ſpiral Courſe thro' Voids immenſe begun,
Ages to roll, and ſwift as Time to run,
Surveying, and ſurvey'd, throughout the Vaſt
Of the Creator's Works from firſt to laſt.*

*Or if, as more ſagacious Sages ſay,
He ſtands faſt fix'd amidſt a Flood of Day,
Around his Orb harmonious Planets race,
By his Attraction mov'd, thro' boundleſs Space.
—— Hail ſacred Source of inexhauſted Light !
Prodigious Inſtance of creating Might !
His Diſtance Man's Imagination foils ;
His Numbers ſcarce avail to count the Miles.
His globous Body how immenſely great !
How fierce his Burnings ! How intense his Heat !
As ſwift as Thought he darts his Radiance round,
To diſtant Worlds his System's utmoſt Bound.
Of all the Planets the directing Soul,
That hightens, and invigorates the Whole.*

And Mr. Baker, in his Universe :

*Along the Skies the Sun obliquely rolls,
Forſakes by Turns, and viſits both the Poles.
Diff'rent his Track, but conſtant his Career,
Divides the Times, and meaſures out the Year.*

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*To Climes returns, where freezing Winter reigns,
Unbinds the Glebe, and fructifies the Plains.
The crackling Ice dissolves; the Rivers flow:
Vines crown the Mountain-Tops, and Corn the Vales below.*

Of his genial Influences and Virtue which he communicates to the Earth.

*His Fires the gentle Flame of Life sustain;
Hence Men and Beasts and the innum'rous Train
Of Vegetables thrive; hence spring the Pow'rs
Which breathe in Animals, and bloom in Flow'rs.*
Prize-Verfes, N°. IV. On Astronomy.

And Cowley thus:

*The glorious Ruler of the Morning, so
But looks on Flowers, and strait they grow;
And when his Beams their Light unfold,
Ripens the dull Earth, and warms it into Gold.*

And of his Beams and Lustre, which enlightens the whole Solar System, Mr. Hulse thus poetically descants.

*Around the Sun the Planets Orbs are hurl'd,
That Center, Eye, and Glory of the World.
See from his Orb, array'd in all it's Pride,
A spreading Lustre streams on ev'ry Side,
And in a Moment gilds the mighty Void!
His Orb so rich, his Beams so swift and bright,
Proclaim the God that made him infinite!*

Euphras. As the glorious Orb of the Sun appears in all Ages the same, pray what did the Antients think of it, *Cleonicus*?

Cleon. Think, why they understood so little of Nature, exercised so little Reason, and were so very superstitious and devout, that, in short, they made a God of him, and really worshipped him as such, under the Titles of *Phæbus*, *Apollo*, &c. as you will find at large in the *Pantheon*. And the Case is the same at this Day with the barbarous *Indians*, *Chinese*, and other Nations abroad. Nay, our *Sabbath* is called *Sun-day*, as being the

the Day appropriated to the Worship of the SUN by our idolatrous Ancestors, the Saxons.

Euphros. There's no Doubt but they worshipped him as the God of Day, Light, and Heat; but what other Characters did he sustain among them?

Cleon. They esteemed him also the God of Wisdom and Harmony; they painted Apollo with his Harp; and from the consummate Beauty, Order, and Regularity which they observed in the Disposition, and Motion of the heavenly Bodies, they assigned them all to his Dominion, and thence their Poets are often chanting the Music of the Spheres, as we shall hereafter see.

Euphros. Pray, Cleonicus, has the Sun any great Influence on the Weather, by which its Alterations can be foretold?

Cleon. Yes, Sister, he has Influence enough on the Atmosphere, and his Heat is the general Cause of all Meteors, and Variety of Weather; and, indeed, by viewing his Orb thro' the Body of Air, variously modified and altered by Vapours, they who are used to it, as Husband-men, Shepherds, &c. may become so Weather-wise, as often to foretel the Changes that will happen in it. And so far the Precepts of Virgil are pertinent. Thus, of the rising Sun:

————— The Sun, who never lies,
Foretels the Change of Weather in the Skies.
For if he rise, unwilling, to his Race,
Clouds on his Brow, and Spots upon his Face;
Or, if thro' Mists, he shoots his fullen Beams,
Frugal of Light, in loose and straggling Streams,
Suspect a drizzling Day, with southern Rain,
Fatal to Fruits, and Flocks, and promis'd Grain.
Or if Aurora, with half-open'd Eyes,
And a pale, sickly Cheek, salute the Skies;
How shall the Vine, with tender Leaves, defend
Her teeming Clusters, when the Storms descend?
When ridgy Roofs and Tiles can scarce avail
To bar the Ruin of the rattling Hail.

Then of the setting Sun.

But more than all, the setting Sun survey,
When down the Steep of Heav'n he drives the Day.

*For oft we find him finishing his Race,
 With various Colours erring on his Face;
 If fiery red his glowing Globe descends,
 High Winds, and furious Tempest he portends:
 But, if his Cheeks are swoln with livid blue,
 He bodes wet Weather by his wat'ry Hue,
 And break'd with red, a troubled Colour shew;
 That sullen Mixture shall at once declare
 Winds, Rain, and Storms, and elemental War:
 What desp'rate Madman then would venture o'er
 The Frith, or haul his Cables from the Shore?
 But, if with purple Rays he brings the Light,
 And a pure Heav'n resigns to quiet Night,
 No rising Winds, or falling Storms are nigh;
 But northern Breezes through the Forest fly,
 And drive the Rack, and purge the ruffled Sky.
 Th' unerring Sun, by certain Signs, declares
 What the late Ev'n, or early Morn prepares;
 And when the South projects a stormy Day;
 And when the clearing North will puff the Clouds away.*

VIRG. GEOR. I.

Euphros. Well, this is very pretty, and, to be sure, very poetical; and such Observations on the Sun are undoubtedly of Use; but did not they go a Step farther, and suppose the Sun could also foretel future Events?

Cleon. Yes, my *Euphrosyne*, they did; and that to the utmost Superstition of Astrology; and indeed, we find so great a Genius as *Virgil*, employing his Muse on this vain and ludicrous Subject; for thus he proceeds, in the Place last mentioned.

*The Sun reveals the Secrets of the Sky,
 And who dares give the Source of Light the Lye?
 The Change of Empires often he declares,
 Fierce Tumults, hidden Treasons, open Wars;
 He first the Fate of Cæsar did foretel,
 And pity'd Rome, when Rome in Cæsar fell.
 In Iron Clouds conceal'd the public Light,
 And impious Mortals fear'd eternal Night.*

But

But it is no Wonder, if we find *Virgil* making Divination the Subject of Poetry; nor is it impossible for so wise a Man to be a little tainted with the prevailing Doctrine of that Age; and especially, if we consider, that his Father is reported to have been a Servant to one of those *sooth-saying Impostors*.

DIALOGUE VIII.

Of the PLANET MERCURY.

Cleonicus.

THIS Morning, my *Euphrosyne*, proves according to our Wishes; the Heavens are clear, especially towards the auroral East, and will present us with a good Opportunity of viewing that rare Curiosity, the Planet *Mercury*. He is now at his greatest Distance from the Sun, and rises before him. He now answers to his poetical Character, of being the *Herald* of the Gods, and the *Messenger* of *Apollo*; for now, it seems, he does indeed precede his Sovereign, and proclaims to our distant Hemisphere the gladsome Approach of Day.

Euphrosyne. Pray, *Cleonicus*, where is this extraordinary Planet? I never rose so early, with so much Pleasure, as I have done this Morning in Expectation of viewing him.

Cleon. My Chamber-Window commands a Prospect of all the eastern Horizon; let us take a Telescope, and from thence view him before the too great Brightness of the rising Sun obscure him.

Euphros. Let us hasten thither; — your Window commands the Earth as well as Heavens; but, pray, to what Part must I look to see this rare Object?

Cleon. Let me see; — Oh, yonder he faintly appears, just over the Top of the Elm; you'll see him, if you direct your Eye to that Tree.

Euphros. I see him; pray, take the Telescope, and direct it to him.

Cleon. 'Tis done, my *Euphrosyne*; put your Eye to the End of the Tube, and view this *Harbinger* of Day.

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Euphros. I see him; — he appears very small, but round, and somewhat globose; — I see no Spot, or any Thing besides a clear Circle of Light; — he appears of a reddish Complexion in the Glass, tho' very pale without it; — I have lost Sight of him, by moving the Tube.

Cleon. You have seen all that can be seen in him; and you may say now, you have *once* seen *Mercury*.

Euphros. Dear *Cleonicus*, I am obliged to you for it. I think you said, he was next to the Sun in the System.

Cleon. He is so; and yet he is computed to be no less than *Thirty-two Millions of Miles from the Sun*.

Euphros. Indeed! And, pray, can you tell me any Thing of the Magnitude of this Planet?

Cleon. Astronomers compute the Diameter of this Planet to be *Two Thousand Four Hundred and Sixty Miles*; and, therefore, his Body will be a little above a 30th Part as big as our Earth.

Euphros. I think you observed to me, his Nearness to the Sun is the Reason why he is with so much Difficulty, and so seldom seen by us.

Cleon. I did so. He is the nearest of all the Planets to the Sun; and his Orbit so small, with Regard to the Distance of the Earth, that when he is in that Part of his Orbit wherein he appears farthest from the Sun, that will seem but a small Space in the Heavens; and so must be taken just after Sun-set, or before Sun-rising, according as he is East or West of the Sun.

Euphros. I remember you told me, when you shewed me the Motions of the Planets in the *Planetarium*, that you could assist me yet farther by a Scheme, in understanding what relates to the Motions and Aspects of the Planets; have you any such Thing by you, *Cleonicus*?

Cleon. Yes; I have a Diagram of the Orbits of the *Earth*, *Venus* and *Mercury*, with the Sun in the Center — Here it is.

Euphros. Very good; I see the Earth at T in the Outermost, and the Letters N, E, S, W, I suppose denotes the North, East, South and West Points of its Orbit; am I right?

Cleon. Yes, my *Euphrosyne*; you will easily apprehend the Theory of the two inferior Planets, *Mercury* and *Venus*, from this Draught, I find.

Euphros.

Euphros. *Cleonicus*, don't flatter me. — In that inmost Circle or Orbit, the Globes I see at M, N, O, P, &c. I suppose represent *Mercury* in so many Points of his Orbit, do they not?

Cleon. Yes, they do; and first, when *Mercury* is in the Point M, he appears to the Earth, at T, to be in the same Part of the Heavens with the Sun, and so is said to be conjoined with the Sun; from whence that Point is called the *inferior Conjunction* of the Planet.

Euphros. Since the Planet is then between the Earth and the Sun, does he not appear to go across the Face of the Sun?

Cleon. Sometimes it so happens, but very seldom; because *Mercury* does not move in the Plane of the Earth's Orbit. When he chances to traverse the Sun's Face, he appears like a black Spot in the Sun; thus I saw him in the Years 1736, and 1743; and he may be seen again in the following Years, *viz.* 1756, 1769, 1776, 1782, 1789, in *October*. And in the Years 1753, 1786, 1799, in the Month of *April*, he will transfit the Sun's Disk, as the great Dr. *Halley* has certainly predicted.

Euphros. It seems to me from the Scheme, that this Planet must be again in Conjunction with the Sun in the Point O of its Orbit; for they are there both in the same Line from the Earth.

Cleon. 'Tis very true, and that is called the *superior Conjunction* of *Mercury*. In that Situation he is never seen; for he either goes behind the Sun, and so is totally eclipsed; or if not, he is so near the Sun, and so small, that he is wholly obscured by the Sun's transcendent Light.

Euphros. Does not the Difference of his Distances in these two Conjunctions make a proportional Difference in his apparent Bulk? I think you told me so, *Cleonicus*.

Cleon. Yes, I did; for as he is above twice as far from the Earth in the Point O, as when he is in M, so he appears almost thrice as big in M, as he does in O, as they find, who have observed him in these Places with good Telescopes. The Positions of the Planet at N and P, are those in the middle Points between the Conjunctions.

Euphros. But how comes it to have that particular Situation at R, in the Scheme?

Cleon. Because that is the Part of the Orbit in which he appears to be at the greatest Distance from the Sun, and which he possesses

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possesses at this Time; for a strait Line T R, drawn thro' the Centers of the Earth and Planet, does but just touch its Orbit. In this Case, he is said to be in his *greatest Elongation from the Sun*.

Euphros. I believe I apprehend you; for a Line joining the Centers of the Earth and Planet in any other Situation H I, would be nearer the Sun. But, which Way does the Planet move in its Orbit?

Cleon. I thought your Memory would have let nothing slip; but you will easily recollect, that it moves from M to R, and so by N to O and P. That is, it moves from the *North* to the *West*, to the *South* and *East*, if I may be allowed so to express it.

Euphros. Then I see, while *Mercury* passes through the Right-hand Half of its Orbit from M by N to O, he will be seen on the West Side of the Sun; and while he marches through the other Half O P M, he will appear Eastward of the Sun.

Cleon. Very right, my *Euphrosyne*; he will so; and therefore from the Time of his inferior to his superior Conjunction, he will *rise and set before the Sun*; but from his superior Conjunction to his inferior, he will *rise and set after the Sun*; in which Case, he will be visible only in the Evening; in the other, (which is the present Case) he can be seen only in the Morning.

Euphros. This is all very plain; and I remember you told me in a general Way, that he made his Tour about the Sun in 88 Days; but, pray, what is the precise Time of Period?

Cleon. *Mercury* revolves about the Sun in the Space of 87 Days, 23 Hours, and 16 Minutes, wherefore the Year to the *Mercurians* is about one Quarter of our Year.

Euphros. Now you talk of the Inhabitants of *Mercury*, pray, if there be any, how is it possible they should endure the excessive Heat of the Sun there, being so near to him?

Cleon. The Heat there must be about seven Times as hot as our Torrid Zone; but the Bodies of Animals and Vegetables, if any, must be tempered accordingly to sustain it. It is an equal Task to Omnipotence to make a Class of Beings as fit to endure one Degree of Heat or Cold, as another. Mr. Baker has some fine Lines on this Head.

and LADY'S PHILOSOPHY. 47

*First MERCURY, amidst full Tides of Light,
Rolls next the SUN, thro' his small Circle bright.
All that dwell there must be refin'd and pure;
Bodies, like ours, such Ardour can't endure.
Our EARTH would blaze beneath so fierce a Ray,
And all its Marble Mountains melt away. Universe.*

Also, thus Mr. Brown in his Prize-Verfes on Astronomy:

*In the near Neighbourhood of Phœbus' Car.
Rolls, swiftly circl'ing, the Mercurial Star;
Obscure he moves, immers'd in Floods of Light,
And seldom greets the nice Observer's Sight:
Then most conspicuous, when th' eclipsing Moon,
With interposing Shadow, veils the Sun. N°. IV.*

And again in N°. III.

*First verging on the lucid Fount of Day,
Bright MERCURY directs his circling Way;
In three short Months he rounds the solar Sphere;
His Seasons shift, and ends his transient Year.*

Euphros. I suppose it was from this quick Motion of his, that he obtained the Post held among the Gods; at least, I learn this Hint from the *Pantheon*, in which I have been pretty conversant since you referred me to it in our last Conference about the Sun.

Cleon. Yes, he was, from the Velocity of his Motion, considered Mythologically, as the *Messenger* of the Gods, by the Poets of those fabulous Ages; his Office was denoted by emblematical Wings on his Head and Feet, and his *Caduceus*, or Rod of Authority, entwined by two winged Serpents, which he carried in his Hand; and thus he is described by *Virgil*, when sent by *Jupiter* to prepare a kind Reception for *Æneas* among the *Carthaginians*.

*Down from the Steep of Heav'n Cyllenius flies,
And cleaves with all his Wings the yielding Skies:
Soon on the Lybian Shore descends the God;
Performs his Message, and displays his Rod. ÆNEID I.*

Some-

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Some Time after, he receives a Commission from *Jupiter*, to order *Aeneas* to retreat from *Carthage*, in the following Lines :

*He calls Cyllenius, and the God attends ;
By whom his menacing Command he sends.
Go, mount the western Winds, and cleave the Sky,
Then, with a swift Descent, to Carthage fly ;
There find the Trojan Chief. ———*

His Instruction given,

*Hermes obeys ; with golden Pinions binds
His flying Feet, and mounts the western Winds :
And whether o'er the Seas, or Earth he flies,
With rapid Force, they bear him down the Skies.
But first, he grasps within his awful Hand,
The Mark of Sov'reign Power, his Magic Wand :
With this, he draws the Ghosts from hollow Graves,
With this, he drives them down the Stygian Waves ;
With this, he seals in Sleep, the wakeful Sight ;
And Eyes, tho' clos'd in Death, restores to Light.*

ÆNEID IV.

DIALOGUE IX.

Of the PLANET VENUS.

Euphrosyne.

DEAR *Cleonicus*, this Morning you entertained me with an Account of the Planet *Mercury* ; and, if you think fit, we will spend this Evening in discoursing of *Venus*, which you said was next to *Mercury*, in the System.

Cleon. Nothing will be more agreeable to me, *Euphrosyne* ; and it happens very opportunely for us, that *Venus* is now also in her greatest Elongation, or farthest Distance from the Sun, and therefore will, in this clear Evening, afford us a most splendid Appearance. It is but stepping Without-doors, and looking Westward, you'll see her Ladyship very brilliant.

Euphros.

and LADY'S PHILOSOPHY. 49

Euphros. I believe I do; for I presume it is that large, bright Star, that appears alone in the Heavens over yonder Hill.

Cleon. Yes, that is she; let us take a Walk to the Hill, and there view her with the Telescope on the same Gate we viewed the Sun.

Euphros. With all my Heart, dear *Cleonicus*; come away; I long to see her Face in the Optic-Glass.

Cleon. As we go over these three or four pleasant Fields, let us view her Orbit in the little Scheme we used in the Morning.
—— Here it is. *

Euphros. Very good; I see *Venus's* Orbit; — it is that which lies between *Mercury* and the *Earth*.

Cleon. It is so; and for that Reason, she has the same Appearances, with Respect to the Earth, as *Mercury* had, viz. she has an *inferior Conjunction* at V, and a *superior One* at D; and while she passeth from V by B to D, she is seen at the Earth T on the *West Side* of the Sun; and while she goes from D by F to V, she appears on the *East Side* of the Sun.

Euphros. Then also, when she is West of the Sun, she rises and sets before him; and when East, she sets and rises after him, as you said of *Mercury*; I presume I am right, *Cleonicus*.

Cleon. Very right, Sister; and for that Reason, she appears, in the first Case, only in the *Mornings*, and in the latter, only in the *Evenings*; on which Account (because she is bright and appears first) she is called the *Morning* and the *Evening Star*, by Way of Preheminence. Accordingly Mr. *Baker* thus describes her:

*Fair VENUS next fulfils her larger Round,
With softer Beams, and milder Glory crown'd;
Friend to Mankind, she glitters from afar,
Now the bright Ev'ning, now the Morning Star.*

UNIVERSE.

Euphros. On the same Account, I suppose, it was, that she had the Name of *Phosphor* and *Vesper*, among the heathen Poets; for you must know, I am now so well read in the *Pantheon*,

H

that

* The Reader is referred to Plate V. Page 25. for every Thing that relates to the Theories of *Mercury* and *Venus* in the last, and present Dialogue.

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that I can quote Chapter and Verse for almost any Thing you find in the Heavens.

Cleon. Thus it was, indeed ; for when she was the *Morning Star*, the *Greeks* called her *Phosphor*, and the *Latins* called her *Lucifer*, both which Names import she ushered in the *Light*, and *Day*; and when she was the *Evening Star* she was called *Vesper*, and *Hesperus*, by the *Greeks*; which Names also signify the *Evening*, or *Close of Day*, among those People. Thus Mr. *Brown*.

*But see! how gentle Vesper, sweetly gay,
Leads the fair Ev'ning with her silver Ray,
Now gilds the Night, now ushers in the Day.*

Prize Verses, N^o. I.

And again,

*See! Venus next reveals her pleasing Ray,
Now leading on, now closing up the Day.
Term'd Phosphor, when her Morning Beams she yields,
And Hesp'rus, when her Ray the Ev'ning gilds.*

Prize Verses, N^o. IV.

Euphros. Give me the Diagram once more, *Cleonicus*, there is one Thing which does not appear to me very plain yet, and that is this; you often say, that the Planets all move from the *West* by the *South* to the *East*, and from thence by the *North* to the *West* again; but if so, as I know they do, and saw very plainly in the *Planetarium*, how is it they appear to go backwards in the Heavens? I remember, you told me, I should be better enabled to understand this Matter by a proper Diagram.

Cleon. I did, my *Euphrosyne*; and you will find it easy to conceive by attending to the Scheme (Plate V.) in the following Manner, viz.

First, While *Venus* moves from her greatest *Western Elongation* A by B, D, and F, to her greatest *Eastern Elongation* at G, the *Apparent Motion* is the same Way as the *True*; and then she is said to be *direct* in Motion.

Secondly, But when *Venus* moves from G by V to A, she will appear to an Inhabitant of the Earth at T, to move back again from *East* to *West*; which is *contrary to her true Motion*, and she is then said to be *Retrograde*.

Thirdly,

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Thirdly, When she is about the Points G and A, she will not appear to move at all for the Space of a few Days; and then she is said to be *Stationary*. This will more easily appear, if you consider, that the Planet is seen by a Ray of Light coming from it to the Spectator's Eye at T, as T A, T B, T C, T D, &c. Now the Planet at A makes the Ray T A fall farthest of all from the Ray T S, which passes thro' the Sun, and thence the Planet, in that Situation, is said to be *most of all elongated* from the Sun. As it passes from thence to B, the Ray T B comes nearest to T S, or the Sun; and still nearer, when arrived at C, and quite in Conjunction at D; and after that, the Planet carries the Ray from the Sun on the other Side towards the East, 'till it arrives to the Situation G; in which Point the Ray T G makes the greatest Angle of Distance on that Side with the Ray T S. After this, as the Planet goes on from G to V, the Ray returns back, and makes the Planet *retrograde* to the Sun; and as it proceeds from V to A, the Ray goes back still, 'till it arrives at its first Situation at T A; and then it goes *forwards* as before.

Euphros. I understand perfectly well what you have said; and the same Things I see true of the Planet *Mercury*, viz. that he is seen at the greatest Distance from the Sun on the West by the Ray T R, which shews him among the Stars at Q; and on the East by the Ray T Z, by which he appears in the Heavens at X; and that during his Passage from R by O to Z, he is *direct* in Motion; but while he moves from Z by M to R, the Ray goes *back again*, and shews the Planet *retrograde* from X by W to Q. I believe I am right, *Cleonicus*, and that I shall be a Piece of an Astronomer by-and-by.

Cleon. You take Things so readily, my *Euphrosyne*, that I make no Doubt of your being an *Adept* in the Science soon; however, one Thing you have not observed, viz. that since *Mercury* appears to describe the same Space in the Heavens QX while he describes very unequal Parts of his Orbit R O Z and Z M R, he must necessarily appear to move much *slower*, when he is *direct* in Motion, and swifter, when he is *retrograde*; which is still more evidently the Case of *Venus*, where the Arches A D G and G V A are much more unequal. — Accordingly Mr. Brown —

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*She forward moves, now pausing, fix'd appears,
Or wand'ring retrograde among the Spheres.*

Prize Verses, N^o. IV.

But we are now arrived at the pleasant Eminence which commands in so fine a Manner, the Western Horizon. See the illustrious Star! how bright she shines in Defiance of the Twilight, which veils, as yet, the more distant Stars from Sight.

Euphros. I see her, exceeding bright indeed! and, if I mistake not, she casts a sensible Shadow.

Cleon. She does, indeed; the Poet might well term her the lesser Moon.

*Next Venus, matchless for her brilliant Light,
Seems as the lesser Cynthia of the Night.*

Yea, so large and bright was this Planet some Years ago, that almost half the Nation took her for a Comet.

Euphros. They could not chuse but be notable Astronomers that made such a Mistake. — But, tell me, *Cleonicus*, is not this the Star that hath sometimes appeared in the Day-time while the Sun has shone?

Cleon. The very same; I do assure you, my *Euphrosyne*, I have seen her look forth with a serene Brightness through the Refulgence of Solar Light.

*No Stars besides their Radiance can display
In Phœbus' Presence, the dread Lord of Day;
Ev'n Cynthia's Self, tho' Regent of the Night,
Is quite obscur'd by his emergent Light;
But Venus only, as if more divine,
With Phœbus dares in Part'nership to shine.*

Euphros. Well! she's a matchless Planet, certainly, and I long to have a more intimate Acquaintance with her; therefore let me view her Complexion, and see what Aspect she puts on to the Astronomer,

Cleon. That you shall do instantly; — this Gate is of a convenient Height; — there, the Tube is fixed, *Euphrosyne*, look thro' it in that Position,

Euphros.

Euphros. What is it I see! — not that bright, that glaring Star, — if so, the Glass divests her of all her radiant Glory, — she seems a Moon in Truth; — a Moon in the first Quarter; — large as the Moon to the naked Eye; — but some-what more vivid, yet serene; — her Horns point upwards: — But why does she not appear with a full Face? — Is the Fault in the Glass, or what is the Reason?

Cleon. The Glass shews all of her that can be seen; the Reason why you see only Part of her Orb enlightened is evident from the Scheme; for let us suppose she were viewed from her superior Conjunction at D; then, because all that Part of the Body which is turned towards the Sun is seen also from the Earth; she must then appear *wholly enlightened*, and like the *Moon at full*.

Secondly, If she were viewed in the Point A or G, then but half her enlightened Face could be seen at the Earth, and therefore she would appear as the *Moon of a Quarter old*.

Thirdly, if we suppose her at V, in her inferior Conjunction; then all her light Part being turned to the Sun, nothing but her dark Part can be towards the Earth; and, like the *New Moon*, she disappears, and can't be seen, even with a Telescope, unless it be in the Face of the Sun.

Fourthly, In the Points B, more than half her enlightened Disk will appear at the Earth, and in the Point C still more than before; therefore in those Places she will appear gibbous.

Fifthly, In the Point X, between V and A or G, she will appear horned, like the Moon about 3 or 4 Days old; which is the present Case of this Planet.

Euphros. But there is something which yet seems strange, and that is, *Venus* is now brightest, and yet but a small Part of her enlightened Surface is towards us; pray, *Cleonicus*, as we walk home, give me to understand the Reason thereof.

Cleon. That you will easily perceive from the Scheme; for, *first*, if the Planet be at D, she will indeed be a *Full Moon*; but then she will be near three times farther from the Earth T than she is now at X, and consequently, she will appear 7 or 8 Times less there (provided she could be seen) than at X; tho' there we see but a Quarter of her enlightened Side, yet that will appear larger and more brilliant than her whole Hemisphere at D.

Again,

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Again, at, and about her upper Conjunction at I, she cannot be seen by Reason of her Nearness to the Sun; but getting farther out of the Sun-Beams, she augments her apparent Size, and Lustre, 'till she comes near the Point X, where it is greatest of all, as before said, and then she is about 40 Degrees distant from the Sun.

Euphros. I presume, *Cleonicus*, I apprehend you full well; and thus, I suppose, as she approaches to V, we gradually lose Sight of her again. —

Cleon. Yes, unless she should chance to pass over the Sun's Disk, or Face (as I said of *Mercury*) in her inferior Conjunction; and this she will do in the Years 1761, 1769, 1996, 2004 in the Month of *June*; and in the Years 1874, 2109, 2117 in *December*; at which Times she will appear a black, but beautiful Spot in the Sun.*

Euphros. Pray, how far is the Orbit of *Venus* from the Sun?

Cleon. About *Fifty-nine Millions of Miles*, that is, about twice as far off as *Mercury*; and therefore the *Light* and *Heat*, at *Venus*, will be but about a *fourth Part* of what it is at *Mercury*; and twice as great as ours.

Euphros. I recollect, you told me *Venus* spent 225 Days in revolving annually about the Sun; but pray, *Cleonicus*, has she any Motion about her own Axis?

Cleon. Some say, she has a diurnal Motion in 23 Hours; and others affirm, it is in 24 Days and 8 Hours; a very wide Difference indeed! — Such a Motion is discoverable only by Spots; and as I have never had it in my Power to procure a Telescope that would shew them, I can say but little about this Matter.

Euphros. What you now say is very extraordinary; I suppose those Instruments are vastly expensive; but if they are, one would think there were People of Fortune enough to render them more common, and to oblige every curious Person with the Use of them upon such Occasions. — But say, what is the Magnitude of *Venus*?

Cleon. She is computed to be a Globe of *Seven Thousand Nine Hundred and Six Miles in Diameter*; and is therefore about 36 Times bigger than *Mercury*.

Euphros.

* Of this curious Phænomenon we shall give a much larger and more particular Account in another Part of this Work.

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Euphros. Well! I think we have talked her Ladyship out of Sight; for I can see her no where now.

Cleon. She is now gone to greet the jovial Sailors on the Western Seas. For you know she is, and ever was, the most of any Star admired and adored both by Land and Sea; and such prodigious Veneration had the Ancients for her, that they made her their Favourite Goddess, and gave her all that Deity itself could claim. Thus one of their Poets sings of her.

*Delight of human Kind and Gods above,
Parent of Rome, propitious Queen of Love!
Whose vital Power, Earth, Air, and Sea, supplies;
And breeds what'er is born beneath the Skies.
For every Kind, by thy prolific Might,
Springs, and beholds the Regions of the Light.
Thee, Goddess! thee, the Clouds and Tempests fear,
And at thy pleasing Presence disappear.
For thee the Land in fragrant Flowers is dress'd;
For thee the Ocean smiles, and smooths her wavy Breast,
And Heav'n itself with more serene and purer Light is blest'd.*

DRYD. LUCRET.

DIALOGUE IX.

Of the EARTH; considered as a PLANET.

Euphrosyne.

THE next Orbit to *Venus* in the Solar System, I see, is that of the Earth.

Cleon. Yes; and thus Mr. Baker elegantly describes the Earth's Motion.

*More distant still our Earth comes rolling on,
And forms a wider Circle round the Sun;
With her the Moon, Companion ever dear!
Her Course attending thro' the shining Year.*

UNIVERSE.

Thus

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Thus also Mr. Brown;

*Lo! in the Midst, fair Earth, our native Seat,
And her attendant Moon their Course repeat.*

Euphros. At what Distance is the Earth's Orbit from the Sun?

Cleon. The Earth is removed to the Distance of about 80 Millions of Miles, which is such a convenient Situation in the System, with Respect to *Light* and *Heat*, as admits of no Excess of either. And therefore Sir R. Blackmore's religious Reflection on this Subject was very judiciously made.

*See! how the EARTH has gain'd that very Place,
Which, of all others in the boundless Space,
Is most convenient, and will best conduce
To the wise Ends required for Nature's Use.
You, who the Mind and Cause supreme deny,
Nor on his Aid to form the World rely,
Must grant, had perfect Wisdom been employ'd
To find, thro' all th' interminable Void,
A Seat most proper, and which best became
The Earth and Sea, it must have been the same.*

CREATION.

Euphros. In what Time does the Earth make a compleat Revolution in its Orbit?

Cleon. In the Space of *Three Hundred Sixty-five Days* and a *Quarter*; which makes what we call our *Solar Year*. This is called the Earth's *Annual Motion*.

Euphros. I remember you mentioned another Motion of the Earth, which I have not yet seen in the *Planetarium*.

Cleon. Yes, my *Euphrosyne*; it has another Motion about its own Axis once in 24 Hours nearly, which is the Space of a natural Day; this is called the *Diurnal Motion*, and is the Cause of *Day and Night*; as the *Annual* or *Yearly Motion* is that from which the various *Seasons of the Year* result.

*Her Central Motions give the Night and Day,
And changing Seasons wait her annual Way.*

Prize Verses, N°. IV.

Or

Or thus;

*The Earth, obliquely circling round her Sphere,
Leads on the varying Seasons of the Year;
Whilst on her Axis she revolves with Speed;
The Days and Nights alternately succeed.*

ANONYMOUS.

But the particular Manner in which the Vicissitudes of Seasons, and of Day and Night, are occasioned and come to pass, I shall take an Opportunity to explain to you another Time.

Euphros. You are very obliging, *Cleonicus*; but, pray, let me ask you why the Orbit of the Earth is represented with all those Divisions and Figures about it?

Cleon. I will tell you, my *Euphrosyne*; the Orbit of the Earth is of great Consequence, and therefore requires to be distinguished from the rest; for though it be the *real Path of the Earth*, it is the visible or apparent annual Path, or Way of the Sun through the Heavens; and therefore, to denote the Sun's Place in the Heavens at any Time, the Astronomers have divided the whole Circle of his Motion into 360 equal Parts, which they call *Degrees*, and every 30 of these they call a *Sign*, of which there will be Twelve of Course.

Euphros. I observe, the Orbit is so divided as you speak of; and I suppose those Characters which I see, denote those Signs respectively, but what are their Names, *Cleonicus*?

Cleon. The Names and Characters are as follow:

1. ♈, *Aries*, the Ram.
2. ♉, *Taurus*, the Bull.
3. ♊, *Gemini*, the Twins.
4. ♋, *Cancer*, the Crab.
5. ♌, *Leo*, the Lion.
6. ♍, *Virgo*, the Virgin.
7. ♎, *Libra*, the Ballance.
8. ♏, *Scorpio*, the Scorpion.
9. ♐, *Sagittarius*, the Bow-man.
10. ♑, *Capricornus*, the horned Goat.
11. ♒, *Aquarius*, the Waterer.
12. ♓, *Pisces*, the Fishes.

I

Euphros.

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Euphros. What is the Reason they have such Names given them?

Cleon. These are the Names of such Constellations of Stars as formerly occupied the Parts of the Heavens where the Signs are, but those Stars are now removed forwards to other Signs, and have left only their Names behind; as we shall hereafter see.

Euphros. I think this Orbit, thus divided into Signs, is what you call the *Ecliptic* on the Planetarium; is it not, *Cleonicus*?

Cleon. The very same, my *Euphrosyne*; it is called the *Ecliptic*, because, as it is the visible Path of the Sun through the Heavens, all the *Eclipses* must happen therein, as you will sometime hence observe more sensibly.

Euphros. As there are 360 Degrees in the *Ecliptic*, and but 365 Days in the Year, I find the Earth must pass over one of those Degrees very nearly each Day.

Cleon. Yes, my *Euphrosyne*, it does so; each Degree is supposed to consist of 60 *Minutes*, thus marked ($'$); and each *Minute* of 60 *Seconds* ($''$); each Second of 60 *Thirds* ($'''$); and so on. And the Earth each Day moves, at a Mean, $59' : 8''$ of a Degree.

Euphros. Well! I shall, by-and-by, not only *think*, but *speak* like an *Astronomer*; as you make the first Sign (and consequently the Beginning of the *Ecliptic*) to begin with the first Degree of *Aries*, pray, to what Day of the Year does this Point answer?

Cleon. According to the present New Style, it answers to the 21st of *March*; when the Sun is said to be in the *Vernal Equinox*, for Reasons you will hereafter be acquainted with.

Euphros. Is the Orbit of the Earth a perfect Circle?

Cleon. No, it is not; though it differs not much from it, yet it makes a sensible Difference in the Earth's Motion; for the Orbit being a little Elliptical, will cause that the Sun will be nearer the Earth at one Time than another; and that will make the Earth move a small Matter faster in one Part than it does in another, and consequently that it will take up more Time, or a greater Number of Days in describing one half of its Orbit, than it requires for the other; thus in passing through the six Signs ♈, ♉, ♊, ♋, ♌, ♍, it takes up 8 Days less, than

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than in passing through the other six summer Signs, as you may understand by placing the Months and Days as follow :

Summer Months.

In March $10\frac{1}{2}$

April 30

May 31

June 30

July 31

August 31

September 23

Summer $186\frac{1}{2}$

Winter $178\frac{1}{2}$

Winter Months.

September 7

October 31

November 30

December 31

January 31

February 28

March $20\frac{1}{2}$

$178\frac{1}{2}$

Difference 8 Days.

Euphros. Well, I never observed this before, though it be so evident from the common Almanack; but, *Cleonicus*, if our quicker Motion in the Winter proves we are then nearer the Sun, how comes it to pass the Sun then seems farthest from us, and that so much the coldest Seasons of the Year?

Cleon. Why, indeed, my *Euphrosyne*, these *Phænomena* are a little *paradoxical*, till you come to see this Matter set in a proper Light under all its Circumstances, and then you will readily allow it must be so.

Euphros. But if the Sun be nearest in the Winter, how is it, that it does not then appear larger than in the Summer?

Cleon. That is well observed, Sister; but the Difference of Distance is so very small as to make no sensible Difference in his apparent Magnitude; yet, were you to measure it with a *Micrometer* in a Telescope, you would find, that when the Sun is in the 8th Degree of ♊ , his Diameter would measure $1967''$, and when in the 8° of ♋ , it measures only $1900''$; less by $67''$ than before, which is near a 30th Part of the Whole. You will at present believe what I say; but when we come to the practical Part of Astronomy, you will find it true by Experiment.

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Euphros. You are very liberal in promising me great Things, *Cleonicus*, I shall be very happy in finding myself capable of them—But, pray, tell me what you know of the Form and Magnitude of the Earth.

Cleon. I will, my *Euphrosyne*; and therefore, first, as to the Figure or Form of the Earth, it is nearly that of a Globe or Sphere, as has been found by modern Discoveries most perfectly.

Euphros. Pray, in what Manner do you find this true, by Experiment?

Cleon. Several Ways, Sister, as (1.) If you go directly North or South, you raise or depress the *North-Star* very sensibly, and always to equal Heights for equal Distances that you go; this Experiment I will one Day or other shew you. Now were you to walk ever so far on a Plane, the said Star would ever appear of the *same Height* above the Horizon. (2.) If you stand on the Sea-coast, you will evidently observe the Convexity of the Surface of the Ocean; but more particularly you will be convinced of this, by observing a Ship sailing directly from you; where you will gradually lose Sight, first, of the Hull or Body of the Ship; and then of the several Sails; and, lastly, the *Tops* of the *Masts* disappear. Now, were the Surface of the Sea a *Plane*, such Appearances could never happen. (3.) The Shadow of the Earth in an *Eclipse* of the Moon is observed to be *circular*, which it could not be unless it proceeded from a spherical Body.

Euphros. I make no Question now of the globular Figure of the Earth, you have given sufficient Proofs of it; and because I think it a Matter so easily, and so fully proved by the two Observations you first mentioned; I wonder very much the Ancients should be ignorant of it, or ever make any Difficulty about it.

Cleon. I think, indeed, it is a Matter of Wonder, for the Sages of Antiquity to have so great a Character for Wisdom as they generally have, and yet were so ignorant of the easiest and plainest Things in Nature; they most of them thought the Earth was a plain Surface, like a round Table, and that all below it was *Hades* or *Hell*, or, in short, something they knew not what; and whither the Sun, Moon, and Stars went to, and whence they came, each Evening and Morning, they could not tell. Yea, so very gross were their Conceptions of these Things, that some of them thought the Sun, &c. did actually descend

into

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into the Western Ocean, at Night, and arose out of the Eastern Ocean in the Morning. Thus *Ovid*,

*The Sun did now to western Waves retire,
In Tides to temper his bright World of Fire.*

And it is extreamly diverting to hear *Epicurus* gravely recounting the several Methods by which to solve the daily Miracle of a New Sun kindling up the Lamp of Day, which was extinguished every Night in the Waters of the *Hibernian* Seas. For thus he harangues us,

*And Day may end and tumble down the West,
And sleepy Night fly slowly up the East;
Because the Sun, having now perform'd his Round,
And reach'd, with weary Flames, the utmost Bound
Of finite Heaven, he there puts out the Ray,
Wearied and blunted all the tedious Day
By hind'ring Air, and thus the Flames decay:
Or else, because the Fires absorb'd at Night
There join again, and scatter vigorous Light.
Thus when the Morning Sun begins to rise,
It's Flames lie scatter'd o'er the Eastern Skies;
Then gather'd to a Ball; and this we view
From Ida's Top: this Fame reports as true.
Nor is it strange, that numerous Seeds of Fire
Should to the Eastern Quarter still retire,
Still every Day return and make a Sun.*

CREECH.

Euphras. As they had such awkward Notions of Things they every Day saw, I fancy it must be merry to hear them discourse of such Things as they never saw; for Instance, of their *Heaven* and *Hell*, and their different Opinions of departed Spirits, &c.

Cleon. Very much so indeed; they imagined all above the Sky was *Heaven*, and all below the Earth was *Hell*, as I said but now; nay, they went so far as to find out the Way to *Hell*, if you believe their Poets. Thus *Virgil* describes *Aeneas's* Descent thither.

These

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*These Rites perform'd, the Prince without delay,
Hastes to the nether World, his destin'd Way.
Deep was the Cave; and downward as it went
From the wide Mouth, a rocky rough Descent,
And here th' Access a gloomy Grove defends,
And here th' unnavigable Lake extends.*

ÆNEID VI.

And in another Place;

*To th' Shades you go a down-hill easy Way;
But to return and re-enjoy the Day!
That is a Work, a Labour——*

Thus also Ovid,

*Between thick baleful Yews, the dreary Way
To lowest Hell, thro' dismal Silence lay;
There Stygian Mists infect the Road, and there
New Ghosts, and thin unfuneral'd Souls appear.*

Euphros. No more of this, *Cleonicus*; such horrid Images shock me; it is a miserable Thing to be a mere *Heathen*!—

Cleon. It is so,—without *Honesty*; but the Figure of the Earth is not the Subject of Revelation, my *Euphrosyne*; and some of the Fathers of our Church have as gravely defended the *heathenish* Figure of the Earth, as if they had been the Descendants of *Ptolomy* himself. Nay, not many Ages since, the Doctrine of the *Antipodes* was zealously oppugned as a *damnable Heresy*; and History informs us, that the learned *Spigelius*, Bishop of *Upsal*, suffered Martyrdom at the Stake in its Defence.

Euphros. Well, I could never have thought the Figure of the Earth had been such an important Article of Faith. It is to be hoped we understand Religion better now a Days; for though I can scarce remember every one of the 39 Articles of our Faith, yet I am pretty well satisfied, neither the *Form* nor *Motion* of the Earth are any Part of any of them.

Cleon. They are not; and our Principles and Notions of Religion are much more correct and rational than they were formerly; and to what is this owing, my *Euphrosyne*? To our having a more correct and rational Philosophy; you will find

it

VI.

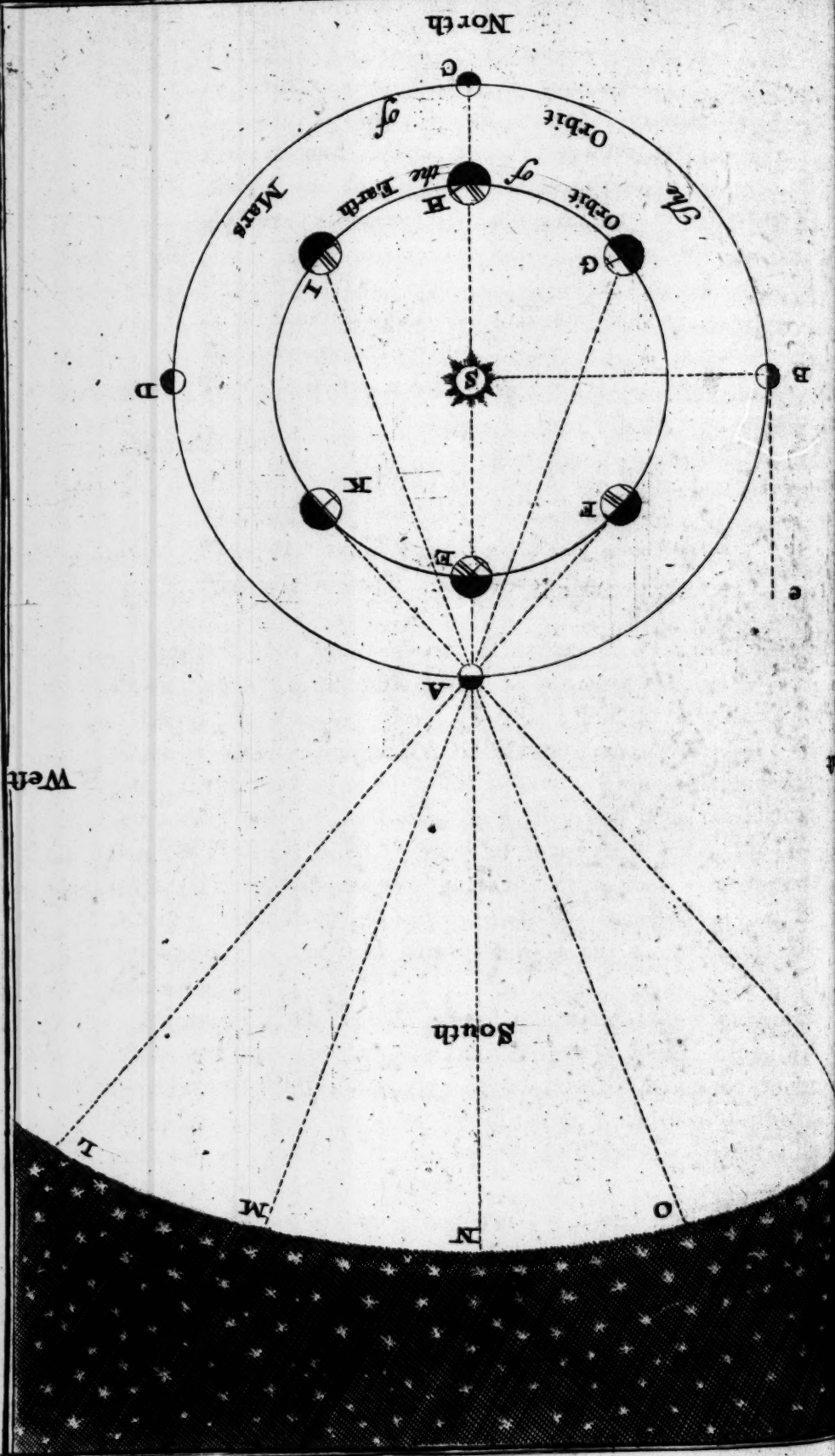
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it a never-failing Maxim, that the better you understand *Philosophy*, the better you will understand *Religion*. But this by the Way—

Euphros. Then let us return to our Subject; and see if I can understand what remains of the Philosophy of the Earth. Pray, what is the Bulk or Magnitude of it?

Cleon. It is about twenty-five Thousand and twenty Miles in Circumference.

Euphros. Well, that is a large Circuit, indeed; *Lord Anson* might very well employ four Years in going round the World.

Cleon. True; but you must consider, in such Voyages it is impossible to go the nearest Way; and they who go round the World, as you call it, go many Thousand Miles more than the Earth is Round, as we shall hereafter see, when you come to the Use of the terrestrial Globe—And this you observe, is another infallible Proof of the Earth's being of a spherical Form; for you may sail almost upon a Circle from *Plymouth* to the *Antipodes*, and find that Distance about half the Number of Miles I before mentioned.

Euphros. You have fully convinced me the Earth is a Globe; but what is the Diameter of the Earth in Miles? I suppose you can tell that, as well as how much it is round.

Cleon. Just as well; the Diameter of every Circle is in respect to its Circumference nearly as 7 to 22, whence that of the Earth will be about 7960 Miles; and it is very remarkable, that the Planet *Venus* is much about as big, for the Diameter of that Planet is computed to be about 7906 Miles, which is but a Trifle less than that of the Earth.

Euphros. So that if we were placed in the Planet, we should view the Earth as large as the Evening-star, but not so bright—

Cleon. You would so, my *Euphrosyne*; but the Phases of the Earth would resemble those of *Mars*, and not of *Venus*. And I dare say you know the Reason of it.

Euphros. Because the Orbit of the Earth is exterior to that of *Venus*—But one Thing I have often thought to ask you, is, why the Earth and all the Planets move always one Way, and in so regular a Manner? Also how they, being such large and heavy Bodies, can keep moving round at the same Distance, and not fall directly to the Sun?

Cleon.

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Cleon. Sir Isaac has shewn perfectly well how they move in Curves by a proper Composition of two Forces acting upon them at once; and the Direction of their Motion was at the Pleasure of the first Mover, for nothing depends on that; therefore, Sir Richard Blackmore's Banter on the Philosophers upon this Subject, proved more his own than their Ignorance, when he thus sneers them.

*This Problem, as Philosophers resolve,
What makes the Globe from East to West revolve?
What is the strong impulsive Cause, declare,
That rolls the pond'rous Orb so swift in Air?
To their vain Answers will you have Recourse,
And tell us 'tis ingenite active Force?
Mobility, or native Power to move,
Words which mean Nothing, and can Nothing prove.*

CREATION.

Thus also the Author of Universal Beauty;

*Say, why this Globe has its appointed Place?
And why not vagrant thro' the boundless Space?
Why here prefer'd, sagacious to refuse
What thwarts Propriety, Convenience, Use?
Why not more Neighbour to the burning Ray,
Or more remote from the declining Day?
Or here not sedentary, fix'd and still?
Admonish'd by no Voice, obsequious to no Will,
Or moving; why in circling Eddies round,
And not progressive thro' th' immense Profound?
Or endless, why the dizzy Drunkard reels,
And round the Sun its annual Motion wheels?
Whence is that innate delegated Power,
Central to spin the swift diurnal Tour?*

Euphras. Why truly, I think a Woman, no wiser than myself, might venture to say, that if the Poetry of these Lines were no better than the Sense, they would be worth no Body's Notice. These Gentlemen might just as well ask, why the Hands of

Clock

Clock move at all? why they move in a Circle? why they move to the right Hand, not to the Left? why they move one faster than the other? why each one always moves an equal Pace? in short, why one is longer, or bigger than the other? these Questions would be just as pertinent, and shew their Skill in Mechanics equal to that in Philosophy.

Cleon. What you have observed is extremely just, my *Euphrosyne*; People often affect to be wise above the Power of human Nature, they are told that *Gravity* gives Motion to all Bodies, but they, forsooth, must know *what Gravity is*, or else condemn it for an *occult Quality*; very good Logic this, Sister, since Gravity is not a *Quality*, nor is it at all *occult*. But we shall wave such idle Curiosity and pursue the useful Speculation of what is permitted us to know. Therefore the Planet *Mars* shall be the Subject of our next Confabulation.

DIALOGUE X.

Of the PLANET MARS.

Euphrosyne.

I Have just been out to view the Sky, and all Things above promise a clear and Star-light Evening to Night.

Cleon. I have observed it; the Heavens have at present a benign Aspect, and will, if the Clouds forbear to rise, be favourable to our Design.—

Euphros. That is, to take a View of the Planet *MARS*, *Cleonicus*; was not that the Conclusion of last Night's Conference?

Cleon. Yes, it was; *Mars* is the next Planet in the System; but of him neither the Poets nor the Philosophers have much to say, as a *Planet*; tho' he bears an illustrious Character among the *Heathen Divinities*. Yet is he not wholly neglected by the Moderns; for thus one:

*See, MARS alone runs his appointed Race,
And measures out exact his destin'd Space;*

K

Nor

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Nor nearer does he wind, nor farther stray,
But finds the Point whence first he roll'd away.

BAKER'S Universe,

Thus another;

And higher see! in thrice our annual Space
Revolving, MARS conclude his longer Race.

Mr. BROWN,

Euphros. What, does the Poet say, *Mars* is two Years revolving in his Orbit about the Sun?

Cleon. Yes; but Poets are seldom to be depended on for Strictness of Truth. *Mars* runs his Race in Six Hundred Eighty-seven Days, which wants 43 Days of Two Years.

Euphros. Pray, what Distance is *Mars* from the Sun?

Cleon. About One Hundred and Twenty-three Millions of Miles; that is, half as far again from the Sun as the Earth: whence the Light and Heat of the Sun at *Mars* is not quite half so much as with us; for it is in Proportion as 43 to 100.

Euphros. Be so good, *Cleonicus*, as to delineate the Orbit of this Planet about the Sun, as you did those of *Venus*, *Mercury*, and the Earth; for my Understanding is much assisted thereby.

Cleon. I will do it immediately, and that of *Mars* will be sufficient for *Jupiter* and *Saturn*; for the *Phænomena* of the three superior Planets are the same in each of them.—* In this Diagram, then, you see the Orbit of *Mars*, and the Planet in the Positions A, B, C, D; within the Orbit of *Mars*, you see the Earth's Orbit, and the Earth at E, F, G, H, I, K; and in the Center S is the Sun.

Euphros. This is all very evident; and here you need not repeat what you have before told me of the general Appearances of this Planet, when you described the whole System to me; but only such as are peculiar to the Planet whose Orbit lies about or beyond that of the Earth. And pray, what are these?

Cleon. They are not many, and are very easy to be understood; for suppose *Mars* at A, and the Earth at E, directly between it and the Sun, then will all the enlighten'd Hemisphere of the Planet

* The Reader is here to keep his Eye on Plate VII. during the above Description of the several Phænomena of the Planet *Mars*.

Planet be turn'd to the Earth, and it appear wholly enlighten'd like the *Full-Moon*. When the Planet is at B, supposing your Eye at *e*, you see one half of his Surface enlighten'd; but if your Eye be removed from *e* to E it is then nearer to, or more towards the Sun, and therefore you will then see more than half the Planet enlighten'd, or he will appear *gibbous*, as they call it, like the Moon a few Days before or after Full. From hence he goes on to C, where it would again appear wholly enlighten'd, were it not in the same Part of the Heavens with the Sun, and so not seen at all. At D again it is gibbous, and so upon the whole you observe the *Phases* of a superior Planet are not so various as those of an inferior one; and in *Jupiter* and *Saturn*, which are very remote from us, nearly the whole Surface will appear constantly illumined. I make no Doubt but you see in general the Reason of all that I have said from the Draught.

Euphros. I flatter myself I do; for the farther the Planet B is removed in that Situation from S, the nearer we may say the Point E is to the Sun at S, and consequently the Planet will appear less gibbous or more enlightened in that Proportion.

Cleon. That is the very Thing, Sister; but all the *Phases* of the Planets are very naturally represented in the Planetarium by placing a Candle in the Center, and putting the Planets in Motion, first the inferior ones, then the superior; you will see them illumined in the same Manner by the Candle as they are in the Heavens by the Sun; and this shall be our Amusement another Time.

Euphros. You take a great deal of Trouble about me, *Cleonicus*, which much endears you to me—but, in the mean Time, what other Peculiarities belong to the superior Planets?

Cleon. One Thing more only, and that is, a superior Planet has one *Conjunction* only, at C; and an *Opposition* at A, which an inferior Planet has not, as I have formerly observed to you.

Euphros. This is indeed very plain; if I view the Planet *Mars* at C from the Earth at E, I see him in the same Part of the Heavens with the Sun at S; and if I view him at A, I see him just in the opposite Part; and therefore when the Sun sets, I may sometimes see *Mars*, *Jupiter*, and *Saturn*, rising; which I well remember you shew'd me, could not be observed of the inferior Planets *Mercury* and *Venus*. But pray, *Cleonicus*, what mean all

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those dotted Lines which pass from the Earth in its several Positions thro' the Planet at A away to the Stars in the upper Part of the Plate?

Cleon. They are to shew how you are to understand that the superior Planets all move (like the inferior ones) in Appearance sometimes *forward*, sometimes *backward*, and are sometimes *stationary* for a While.

Euphros. Then I suppose each of those dotted Lines represents a Ray of Light coming from the Planet to the Eye, and by which we see his apparent Place among the Stars in the Sky; is it not so, *Cleonicus*?

Cleon. You have hit the Case as nicely as if you were *Copernicus's* Great-great-grand-daughter—— And I see from thence that you will have no Difficulty to understand this *Phaenomenon*. For supposing the Earth at F, and the Planet at Rest in its Orbit at A, it will be projected or seen by a Ray of Light among the Stars at L; when the Earth arrives at G the Planet will appear at M by the Ray GM; and in the same Manner at H, I, and K, it will be seen among the Stars at N, O, P, and therefore while the Earth moves over the large Part of it's Orbit F, H, K, the Planet will have an apparent Motion from I to P among the Stars, and this Motion is from *West* to *East* the same Way with the Earth; and so the Planet is said to be *direct* in Motion all this Time. I believe you understand me, Sister.

Euphros. Surely I must, when the Thing is so obvious; and I am of Opinion I know what you are going to say next, *Cleonicus*.

Cleon. Why indeed, my *Euphrosyne*, when the Planet has gone as far as it can *forwards*, 'tis natural to suppose it will there *stop a While* (as it were to breathe) and then return *back again*. For because the Ray of Light at K does nearly coincide with the Earth's Orbit a little Way on one Side and on the other, therefore all the While the Earth is passing thro' this small Part, the Ray will have the same Position nearly, and consequently shew the Planet at Rest at P, for that short Space of Time; in which Case it is then said to be *stationary*.

Euphros. I was a little out in my Conjecture, having almost forgot what you told me heretofore of the *Stations* of *Venus* and *Mercury*. But now I am certain what must next follow from the

the Scheme, and will anticipate your Description of the *Retrograde Motion*; for I plainly enough see that when the Earth moves on from K to E the Planet must appear to return from P to N, and while the Earth moves from E to F the Planet will proceed still retrograde to L, and there again be stationary; is not all this right, *Cleonicus*?

Cleon. Indeed, my *Euphrosyne*, it is; I could not have better expressed it myself; you will by-and-by be an *Adept* in Astronomy. — And I question not but you observe at the same Time, that since the Part of the Orbit which the Earth describes in passing thro' FHK is much greater than the Arch KEF, and the Space LP which the Planet describes in its direct and retrograde Motion is the same; therefore the *direct Motion* is very slow from L to P, in Comparison of the *retrograde Motion* from P to L, which is perform'd in much less Time.

Euphros. All you have said, I see the Reason of from the Diagram as plainly as any Thing can make it.

Cleon. You don't know that, perhaps; I have another Method yet, my *Euphrosyne*, to convey the Idea (in a more lively Manner) of the *direct* and *retrograde Motions* and *Stations* of the Planets, by shewing you the Thing in Reality in the Planetarium just as it appears in the Heaven to our Eye, when we have done with the superior Planets.

Euphros. I think 'tis strange then, if I do not understand it at last; I imagine you look upon this as a difficult Point for an *astronomic Tyro* to comprehend, since you take so much Pains with me about it; do you not *Cleonicus*?

Cleon. Why, I can't say but I think it quite necessary to have a right Understanding of this Affair, as it is a principal and very interesting *Phænomenon*, and what very few People have a clear Notion of. And indeed I must tell you, that as the *Geometricians* have one Proposition in *Euclid* which they call the *Ass's Bridge*, which their Pupils must pass before they can be supposed to understand any Thing in that Science; so you must look upon this Problem in Astronomy in the same ludicrous Light, and think yourself not initiated into the Mysteries of *Urania*, 'till you can clearly account for this *Phænomenon*.

Euphros. Well, I doubt not but when you shew me this in the Planetarium, I shall have a clearer and most compleat Idea
of

of it; you see, I have Courage enough, *Cleonicus*.— But at present, I must ask you the Reason of one Thing, and that is, why you place the Planet at Rest in its Orbit at A, since it is in Reality always in Motion?

Cleon. The Reason is, because I would make the Thing easier for you to apprehend from the Diagram; for the *Phænomenon* is the same in it self, whether you suppose the Planet to be at Rest or in Motion, it only makes a Difference in the *Time* and *Place*, *when* and *where* it happens; as you will be convinced of another Time.

Euphros. Very good, *Cleonicus*; 'till then we will wave this Subject. I want to have a Sight of this Planet; how far is he this Night from the Point A of his Opposition to the Sun?

Cleon. Not a great Way; and therefore he may be very opportunely viewed this Evening, to that End I have prepared and fixed the Telescope for your Sight.

Euphros. The Heavens clear up, the Stars begin to appear more and more bright; pray, which is *Mars* among them all?

Cleon. It is that bright Star which you see high in the Heavens, a little to the East of the Seven Stars; he appears of a *reddish Hue*, and steady Countenance.

Euphros. I see him; pray, level the Telescope to him.—

Cleon. I will,—— It is done, look thro' it.—

Euphros. I see him very plain,—— but he appears very small,—— much smaller than *Venus*—— and redder, —— with almost a round Face;—— but I can see no Spots or any Thing on him,—— he is just passed off the Glafs.—

Cleon. You rightly observe that he appears very small; for he is indeed much less than the *Earth* or *Venus*, being but *Four Thousand four Hundred and forty-four Miles* in Diameter. It is therefore near *Six times less* than the *Earth*.

Euphros. Does this Planet turn round upon its own Axis?

Cleon. Some Astronomers say they have observed divers Spots on his Surface, and from their Motion thereon have supposed, that he revolves about his Axis in 24 Hours and 40 Minutes; and if so, his Days and Nights are much of the same Length with ours. But our Telescope, as you observed, is not sufficient to discover these Spots.

Eu-

Euphros. How comes *Mars* to have such a ruddy Complexion?

Cleon. This is somewhat uncertain; but in all Probability, from a peculiar Sort of Matter of which this Planet consists, which reflects the *red-making Rays* of Light; or from a very thick Atmosphere about him, which we very well know will produce the same Effect. But, be this as it will in Philosophy, 'tis certain this his *sanguine Complexion* entituled him to the Post he bore among the ancient *Pagan Deities*.

Euphros. You mean his being reputed the *God of War and Armies*, I suppose.

Cleon. Yes; and they represented him riding on an high Chariot drawn by two furious Horses, *Fear* and *Terror*, driven by his Sister *Bellona*, the Goddess of War; he was covered with Armour, and held a *Spear* in one Hand, and brandished a *Sword* in the other, threatening Ruin and Desolation to the World. *Virgil* thus describes his Career,—

MARS in the Middle of the shining Shield
Is grav'd, and slides along the liquid Field.
The Diræ come from Heav'n with quick Descent,
And Discord dy'd in Blood, with Garments rent,
Divides the Press; her Steps Bellona treads,
And shakes her Iron Rod above their Heads.

Æneid. 8.

Euphros. However he might be equipped on Earth in Proxy, I fancy he is alone in the Heavens, for I saw thing but himself in the Telescope.

Cleon. Very true, my *Euphrosyne*, he has there no Attendants, no *Satellites*, no *Heralds*, tho' himself be there most glorious. He walks his Round in eternal Solitude, and is the only Planet above *Venus* that traverses the Heavens destitute of Arms and Attendance.

Euphros. It was not, then, with the greatest Propriety that he was elected *God of War*; but, alas! he little thought of the Honours he bore, and how terrible he was to Mortals in his Neighbour-Planet the Earth.

Cleon,

Cleon. You hit the Poet's Thought,——

*In larger Circuit rolls the Orb of MARS,
Guileless of stern Debate and wastful Wars,
As some have erring taught; he journies on,
Impell'd and cherish'd by th' attractive Sun;
Like us, his Seasons and his Day he owes
To the vast Bounty which from Phœbus flows.*

PRIZ. VERS. Numb. IV.

DIALOGUE XI. Of the PLANET JUPITER.

Euphrosyne.

I Remember, in the Planetarium, the next Planet above *Mars* was *Jupiter*, when you represented the *Copernican System*.

Cleon. Yes; it was; the great and wondrous Orb of *Jupiter* rolls next; accordingly *Mr. Baker* thus describes it,——

*Yet more remote from Day's all-cheering Source,
Large JUPITER performs his constant Course:
Four friendly Moons, with borrow'd Lustre, rise,
Bestow their Beams, benign, and light his Skies.*

Universe.

Euphros. Pray, *Cleonicus*, let me see the Plate of the *Solar System*.

Cleon. Here it is.——

Euphros. The Orbit, then, of *Jupiter*, I see; but is it really situated so far from the Sun with respect to the Earth, as it is there drawn?

Cleon. Yes, my *Euphrosyne*; *Jupiter* is a little above five times farther from the Sun than the Earth; that is, he is Four Hundred and twenty-four Millions of Miles from the Sun; and so his Light and Heat is about 32 times less than ours.

Euphros. Well, sure, if there be any Inhabitants in *Jupiter*, they are doomed to a very cold and gloomy State; I quite shudder at the Thoughts of it!

Cleon.

Cleon. They are very cold and dark indeed, when compared with us; but their Natures are suited to it, and so can suffer nothing on that Account. Our Degree of Light and Heat would be as intolerable to them, as theirs of Cold and Darknes would be to us.

Euphros. If I mistake not, I have read that *Jupiter* is the largest of all the Planets.

Cleon. He is so; nay, he is bigger than all the other Planets put together; being no less than *Eighty-one Thousand One Hundred and Fifty-five Miles* in Diameter, which renders him above a *Thousand Times* larger than our Earth.

Thus Mr. Brown:

*Then Jove, prodigious Planet of the Skies!
His Orb presents, of huge amazing Size,
In Bulk none equals his enormous Mass;
The whole joint System his Contents surpass.*

Nº. III.

Euphros. Pray, how long is *Jupiter* revolving his prodigious Orb about the Sun?

Cleon. About twelve Years; or more precisely, in *Four Thousand three Hundred and Thirty Days and an Half*. Consequently his *Summer* and *Winter*, and other Seasons, are almost twelve times as long as ours.

Euphros. And what Length are his Days and Nights, *Cleonicus*?

Cleon. Some have determined a Motion about his own Axis, in the Space of 9 Hours 56 Minutes, from a Spot they have observed to pass over the Disk, or Face, of *Jupiter* in half that Time.

Euphros. Then the Days and Nights are but *Five Hours* long, I find, notwithstanding his Years are so tedious.

Cleon. They are so very short, indeed; and the Plane of *Jupiter's* Orbit being but very little inclined to that of the *Ecliptic*, there is but very little Difference between the Length of Days and Nights throughout the Year. Of his Days and Seasons thus Mr. Brown:

L

In

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In ampler Compass Jove conducts his Sphere,

And later finishes his tedious Year.

Yet swiftly on his Axle turn'd, regains

The frequent Aid of Day to warm his Plains.

Priz. Verf. N°. IV.

Euphros. I observe, from the Diagram, that he as well as *Mars*, has his *Conjunction* with, and *Opposition* to, the *Sun*; and that he is also some-what nearer to the *Earth* at the *Opposition*, than when in *Conjunction*.

Cleon. Yes, my *Euphrosyne*, you rightly observe, that he has all the Particulars which were related of *Mars*; he is sometimes conjoined with, sometimes opposed to the *Sun*; sometimes *Direct* in Motion, sometimes *Retrograde*, and at other times *Stationary*: He is indeed nearer the *Earth* at one Time than another by the Difference of the Diameter of the *Earth's* Orbit; but that is so inconsiderable, that his apparent Magnitude is very little varied thereby. And it is almost all one if *Jupiter* be viewed from the *Earth*, or the central *Sun* itself.

Euphros. But when he is nearest that will be the best Place to observe him with a Telescope.

Cleon. You are very right, my *Euphrosyne*; he is then apparently one-third Part bigger, and shines with the greatest Lustre, and may be conveniently viewed at all times of the Night, when the Weather is clear.

Euphros. And pray how is he situated in his Orbit this Evening? I hope in such a Part as will render him visible.

Cleon. You have your Wishes; if you now step out, you will see him almost culminating, or in the highest Point of the *Zodiac*, shining with a large, pale, and steady Lustre.

Euphros. I'll immediately go, — I believe I see him, — is it not that very large pale Star, on the Left-hand of the *Seven Stars*, and nearly South-west?

Cleon. That is the Planet; 'tis that mighty *Jove*, whom the Heathen adored as the supreme Lord of all; and indeed he appears, compared with the other Stars, to sit as it were, on the Throne of the Heavens, and to preside with Majesty and Glory over all the starry Regions.

Euphros.

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Euphros. I long to see him as much as some People do to see the King. I hope your Telescope is in Order, since the Air is so clear and still to Night.

Cleon. There could not be a finer Evening for the Purpose. This Afternoon I carefully cleaned the Glasses, and fitted the Telescope for Use; let us therefore take it and go out.

Euphros. I'll follow you, *Cleonicus*, pray be expeditious in fixing the Glas. —

Cleon. Trust me, *Euphrosyne*, for that; — the Tube is now well fixed, and you may view in his Face equal Grandeur and Serenity.

Euphros. Grandeur, indeed, I think! — for he appears exceeding large — and equally serene, as you said, — I cannot but admire his wondrous Aspect, — he appears with a full enlightened Face — I see none of those Spots that you spoke of just now — his Face seems all over-spread with a soft, a steady and uninterrupted Glory. — But what are those Belt-like Appearances, which I see go across his Body in one or two Places?

Cleon. They are call'd his Belts, indeed; but what they are is not possible to determine, nor easy to conjecture. Sir *Isaac Newton* speaks of them as *Clouds*, but tho' they vary their Magnitude, and Distances among themselves, yet while they have the same constant Appearance of Zones or Belts, it is somewhat doubtful if they are Clouds formed in *Jupiter's* Atmosphere, as Clouds are formed in ours, in which we observe no Constancy of Form, Position, or any Thing else.

Euphros. Well, but what are those small Stars I see by *Jupiter* — two on one Side and two on the other, at unequal Distances?

Cleon. They are the *Moons* or *Satellites* which give Light to *Jupiter* by Night, as our Moon does to us.

Euphros. Indeed! Do you suppose those very small Stars to be Moons as large as our Moon?

Cleon. Yes, my *Euphrosyne*, and larger by far; our Moon at that Distance would not be visible through the best of Telescopes in use with us. Of these Moons thus Mr. *Brown* :

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*For signal Honour made, behold! afar
Four radiant Moons surround th' imperial Star;
(Large as our boasted World) whose silver Light
Refresh his Regions in the gloomy Night;
Nor this the Fancy of deluded Eyes,
Mark'd are their Periods thro' sublimer Skies.
Oft does th' Astronomer his Tube display
And view 'em in Eclipse with pleas'd Survey.
To this the Curious their Discov'ry owe
Of Light's swift Motion, and its Measure know.*

Euphras. Well, I do not envy *Jupiter* his four Moons, I believe he has Need enough of them. — But how comes it to pass, since *Mars* is situated between us and *Jupiter*, and we having one Moon and *Jupiter* four, that *Mars* has none at all?

Cleon. The Question you start very naturally offers, and is of some Importance, as it concerns the Analogy and Harmony of the several Parts of the great Machinery of our System. But you will excuse me from a direct Answer 'till we come more immediately to consider the Nature of *Moons* or *secondary Planets*, in another Conversation, particularly on that Subject.

Euphras. If you please, *Cleonicus*; — but one Question more — If *Jupiter* be so very large a Planet, pray, what do you think of the Inhabitants there?

Cleon. 'Tis true, one can assert nothing positively of them, but if we reason from the Analogy of Things, they as much exceed us in Stature as *Jupiter's* Globe exceeds ours in Diameter; and are therefore at least sixty Feet high; nor is there any Thing to be wondered at in this, since Things are great and small only by Comparison.

Euphras. I make no Doubt but this Planet made a notable Figure among the Deities of the heathen World in former Times.

Cleon. I need say only this, that he was adored with the greatest Veneration under the Character of the *Most High and supreme Deity*.

Euphras. That is, I suppose, you mean the Heathens worshipped the God and Creator of all Things, who is of himself invisible, under the Shrine of this glorious Planet *Jupiter*.

Cleon.

Cleon. Yes, they did so; and made divers Statues and Images, insomuch that almost every Nation had a *Jupiter* of their own, in Imagery. He was honoured with no less a Title than that of *The Father of the Gods and Men*.

Euphros. How came they originally by the Notion of *Jupiter's* being the supreme Deity?

Cleon. Undoubtedly from the *Hebrew* People: For the supreme God among them being called *Jehovah*, or *Jovah* (as a late learned Bishop says it was pronounced) the Heathens from thence, by an easy Derivation, had their Term *Jovis*, *Jove*, or *Jupiter*, which was the same Deity under different Names; according to the Address of Mr. *Pope's* Prayer,

*Father of all in ev'ry Age,
In every Clime ador'd;
By Saint, by Savage, and by Sage,
Jehovah, Jove, or Lord.*

That is to say; the *Hebrews* called him *Jehovah*; the Heathen, *Jove*; but the better informed *Christians* call him *Lord* of the World.

Euphros. Pray, how did they set off their most high God in the *Pantheon*?

Cleon. He sat on a *Throne* of *Ivory* and *Gold*, under a rich Canopy, with a Beard, holding *Thunder-bolts* in his Right-hand, and a *Sceptre* of *Cypress* in his Left, with an Eagle on the Top, and was invested with an *imbroidered Gloak* and *golden Shoes*.

Euphros. I suppose he was not a more splendid Star in the Heavens, than a sacred and illustrious Theme among the Poets, too.

Cleon. 'Tis very true, he was not, as you will find by a few Citations from them; *Virgil* ascribes a Sort of *Ubiquity* to him in these Words,

*From the great Father of the Gods above
My Muse begins; for all is full of Jove.*

Eclog. 3.

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And in another Place thus :

*The King of Gods and Men, whose awful Hand
Disperses Thunder on the Sea and Land,
Disposing all with absolute Command.*

And again :

*The mighty Thund'rer with majestic Awe
Then shook his Shield and dealt his Bolts around,
And scatter'd Tempests on the teeming Ground.*

Homer ascribes almost all the Attributes of Deity to Jupiter in these Verses :

*O Thou, whose Thunder rends the clouded Air,
Who in the Heav'n of Heav'ns has fix'd thy Throne,
Supreme of Gods ! unbounded, and alone !*

And in another Place,

*So Jove decrees, resistless Lord of all !
At whose Command whole Empires rise or fall :
He shakes the feeble Pomp of human Trust,
And Towns and Armies humbles into Dust.*

DIALOGUE XII.

Of the PLANET SATURN.

Cleonicus.

WELL, my *Euphrosyne*, the Order of our physical Speculations hath brought us at Length to the extreme Parts of the Solar System, I mean the Orbit of *Saturn*, which is the Boundary thereof, if we except the Cometary Orbits.

Euphros. I remember you told me, *Saturn* was the sixth primary Planet, and the highest or most remote from the Sun.

Cleon. Yes.

Farthest

*Farthest and last, scarce warm'd by Phœbus' Ray,
Thro' his wide Orbit, Saturn wheels away.
How great the Change, could we be wafte'd there!
How slow the Seasons! and how long the Year!*

BAKER's Universe.

Euphros. I perceive from the *Copernican System*, that the Orbit of *Saturn* lies very far from the Sun, in Comparison of the rest, and, consequently, that his Circuit is very large indeed.

Cleon. Yes, the Distance of *Saturn* from the Sun is computed to be no less than *Seven Hundred and Seventy-seven Millions of Miles*, which is $9\frac{1}{2}$ times farther than the Earth; and therefore the *Light* and *Heat* at *Saturn* will be 90 times less than it is with us.

Euphros. Ninety times less! Why sure they can neither see nor feel in *Saturn*. Well I thought *Jupiter* was cold enough to think on; but *Saturn* would freeze ones very Thoughts!

Cleon. They are inconceivably cold and dark there to be sure; and this Speculation is the curious Theme of the following Verses.

*From hence how large, how strong the Sun's bright Ball!
But seen from thence, how languid and how small!
When the keen North with all its Fury blows,
Congeals the Floods, and forms the fleecy Snows,
'Tis Heat intense to what can there be known:
Warmer our Poles than is its burning Zone.
Who there inhabit must have other Powers,
Juices, and Veins, and Sense, and Life than ours.
One Moment's Cold, like theirs, would pierce the Bone,
Frieze the Heart's Blood, and turn us all to Stone.*

Universe.

Euphros. Dear Brother, forbear—you make me shiver to hear the cold Strains! can it be possible for any sensible Beings to endure that Intensity of Cold, and live?

Cleon. Yes, undoubtedly; you see very small and tender Animals endure the coldest Water in the Winter Time without any Concern. Yea, I have put those little Creatures into a freezing Mixture made of *Nitre* and *Snow*, which is intensely cold

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cold, and they seem'd not affected with it. Yea, further; I have put these very small Animals into a Tube of Water and froze them in a Cylinder of Ice for the Space of Half an Hour, and yet it has not killed them. You see therefore it is only a Constitution fitted to the Nature of the Element that is necessary to the enduring any Degree of Cold or Heat. As the same ingenious Author observes in the same Place:

*Strange and amazing must the Difference be
'Twixt this dull Planet and bright Mercury;
Yet Reason says, nor can we doubt at all,
Millions of Beings dwell on either Ball,
With Constitutions fitted for that Spot,
Where Providence, all-wise, has fix'd their Lot.*

Euphros. Well, all the Works and Ways of Providence are wonderful; surely they who neglect or despise Philosophy, must be sottish Creatures indeed! they little know the Pleasures that arise from its various and noble Speculations! But not to digress — Pray, how long is the Year in Saturn?

Cleon. About the Length of $29\frac{1}{2}$ of our Years; or more precisely, it consists of *Ten Thousand Seven Hundred Fifty-nine Days and six Hours*; for in that Space of Time Saturn revolves once about the Sun. Of the Saturnian Year a Poet thus sings,

*View Saturn last; how faint his distant Gleam,
(Sublimest Planet in our Solar Scheme)
Tho' vast his Globe, so large his Orbit's Space,
Our Thirty Years but shew his annual Race.*

Priz. Verf. N^o. III.

Euphros. Since his Year and Seasons are so very long, how long may we suppose his Days and Nights to be?

Cleon. It is not yet known whether he turns upon his Axle or not, and therefore nothing certain can be said of his Day or Night. But it is agreeable to the Nature of a Planet to turn on its Axis, and therefore he in all Probability does so, tho' we know it not.

Euphros.

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Euphros. I am a little impatient to have a Sight of this Planet; they say there is a Kind of Ring which encompasses his Body, that makes this Planet a delightful and wondrous Spectacle.

Cleon. There is such a Thing, and to the End that you may have a clear and perfect Sight of this singular and surprising Phenomenon, I have provided you a reflecting Telescope, which magnifies to a very great Degree, and is easily used when fixed on its proper Pedestal.

Euphros. I thank you, dear *Cleonicus*, for the Care you take to pleasure me in this Respect; it is a curious Instrument indeed, and I doubt not but its Use is according.—Is it not yet dark enough to see the Planet?

Cleon. I believe it is nearly, or at least will be by that Time the Tube is mounted.—I will look out—I see him plainly.

Euphros. Pray, shew him to me.

Cleon. You can't miss seeing him; it is that pale bright Star you see towards the North-East, and is the biggest Star that now appears.

Euphros. I see the Star you mean—and long to view him thro' the Telescope; pray, fetch it out, *Cleonicus*.

Cleon. I will—here it is, and I'll fix it for your View;—it is done—look thro' it, my *Euphrosyne*, without touching it.

Euphros. I will—I see both the Planet and its Ring,—a most curious Sight, indeed!—he appears with a round Face, but not so big nor bright as *Jupiter*.—I see the Ring perfectly encircle his Globe—and extends on each Side to a considerable Distance.—I can also see the dark Space, on each Side, between the Planet and its Ring.—I also observe two or three small Stars, which, I suppose, are his Moons, like those I saw in *Jupiter*.—But he is moved quite off the Glass.

Cleon. I question not but you are pleased with so uncommon a Sight. But this Instrument will make it as familiar as you please. You will observe, that he appears *Full-faced*, as indeed he always does, on Account of his prodigious Distance from the Sun in Comparison of us; and also that he appears less than *Jupiter*, for so he, indeed, is by much.

Euphros. Pray, what is the Magnitude, or Bulk of *Saturn*?

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Cleon. He is computed to be *Sixty-seven Thousand Eight Hundred and Seventy Miles* in Diameter; and therefore he is in Bulk about *Six Hundred Times* bigger than our Earth; and a little more than half as big as *Jupiter*.

Euphros. But this wonderful Ring of his, what do you take it to be?

Cleon. The Learned abound with Conjectures about it; but as no Man can possibly know any Thing certainly of the Matter, I think it better to say Nothing; and chuse rather to give you a poetical Description of this extraordinary Phenomenon.

Muse! raise thy Voice, mysterious Truth to sing,
How d'er the copious Orb a lucid Ring,
Opaque and broad, is seen its Arch to spread
Round the big Globe at stated Periods led;
Perhaps (its Use unknown) with gather'd Heat
To aid the Regions of that gelid Seat,
The Want of nearer Phœbus to supply,
And warm with reflex Beams his Summer Sky;
Else might the high plac'd World, expos'd to Frost,
Lie Waste, in one eternal Winter lost.

Prize Vers. No. III.

Euphros. Do you know at what Distance this Ring is situated from the Body of Saturn?

Cleon. The Measures of Astronomers make it to be at the Distance of *Twenty-one Thousand Miles* from Saturn, and also that its Breadth is equal thereto, or, as some say, its Breadth is *Twenty-nine Thousand Miles*.

Euphros. Stupendious Magnitude! what can be the Meaning of it! what the Use? Say, *Cleanicus*.

Cleon. I can say after others, that it may possibly be appointed to give Supplies of *Light* and *Heat* to the Planet; but this Supposition, however plausible, I do not think altogether reasonable; for (1.) The Inhabitants have Constitutions suited to the Temperature of the Globe of Saturn undoubtedly, and therefore can't be said to want more *Light* and *Heat*; our Degree of *Light* might blind them, and our *Heat* would make the Marrow fry out of their Bones, in all Likelihood. (2.) There are, as you ob-

observe, several Moons to make up the requisite Degree of *Light*. And therefore the Use of that wond'rous Ring (tho' very great, to be sure) may be to us entirely unknown.

Euphros. Well, I would not be over inquisitive; 'tis a Pleasure we know there's such a Ring, be the Use of it what it will. But, pray, how many Moons hath *Saturn*?

Cleon. Thro' our common Telescopes we discover but *two* or *three*, tho' with the best Sort you may see *five*, of which I intend to give you a farther Account at another more convenient Time.

Euphros. I have no Occasion to ask concerning his *Conjunctions*, *Oppositions*, *Retrogradations*, &c. which I see, from the Plate, must follow from his being a superior Planet, or having his orbit lying without that of the Earth, as in *Jupiter* and *Mars* you explained to me; and would only observe, that whether he be in Conjunction or Opposition, it appears to me that his apparent Magnitude can be but little varied, because of the much smaller Diameter of the Earth's Orbit than its own.

Cleon. 'Tis well observed, Sister; for there is but little Difference if view'd in the Opposition, when he is nearest; or in the Conjunction, when he is farthest off.

Euphros. Did not the great Distance and long Period of *Saturn*'s Revolution occasion him to be taken Notice of among the Heathens in ancient Times?

Cleon. As to his great Distance, they were far from being Astronomers good enough to know any Thing about that: But his slow Motion, and the great Length of his Year, occasioned them to make him the *Emblem of Time*.

Euphros. In what Manner?

Cleon. They represented him as a decrepid, wrinkled old Man; with a long Beard, and hoary Head; round Shoulder'd, hollow Jaw'd, flat Nosed, hooked Chin'd, black Lips, and crooked Hands. In his Right Hand was a rusty *Scythe*, and in his Left he held a *Serpent biting his Tail*; or, as some say, a Child, which he is about to devour.

Euphros. Why then he made but a Sort of contemptible Figure among Men in Days of old, I find; he was indeed a very fit *Symbol of Time*, which gives to every Thing a horrid Aspect; or cuts down, and devours it; and that in an endless Circulation

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of Ages.—Pray, is there any Thing farther remarkable of Saturn?

Cleon. There are abundance of Things fabled of him, as you may meet with, and doubtless have, in many Books; but the most notable Thing of all is the Time in which he lived, called the *Golden Age*.

Euphras. I have read a Description of that extraordinary Age in some Poet, but forget which.—I should be glad to hear it repeated.

Cleon. *Virgil* gives a beautiful Description thereof in his Eighth Book of *Æneid*; and *Ovid* in his First Book of *Metamorphoses*. Which, since it is agreeable to you, I shall rehearse in Mr. *Dryden's* Language.

The Golden Age was first, when Man, yet new,
No Rule but uncorrupted Reason knew;
And with a native Bent did Good pursue.
Unfore'd by Punishment, unaw'd by Fear,
His Words were simple, and his Soul sincere:
Needless was written Law, where none oppress'd;
The Law of Man was written in his Breast.
No suppliant Crowds before the Judge appear'd;
No Court erected yet, nor Cause was heard;
But all was safe, for Conscience was their Guard.
The Mountain Trees in distant Prospect please,
E'er yet the Pine descended to the Seas;
E'er Sails were spread new Oceans to explore,
And happy Mortals, unconcern'd for more,
Confin'd their Wishes to their native Shore.
No Walls were yet, nor Fence, nor Moat, nor Mound,
Nor Drum was heard, nor Trumpet's angry Sound,
Nor Sword were forg'd: But void of Care and Crime,
The soft Creation slept away their Time;
The teeming Earth, yet guiltless of the Plough,
And unprovok'd, did fruitful Stores allow.
Content with Food which Nature freely bled,
On Wildings and on Strawberries they fed;
Cornels and Bramble-berries gave the rest;
And falling Acorns furnish'd out a Feast.

*The Flow'rs, unsown, in Fields and Meadows reign'd,
And western Winds immortal Spring maintain'd.
In following Years the bearded Corn ensu'd
From Earth unask'd, nor was the Earth renew'd:
From Veins of Vallies Milk and Nectar broke,
And Honey sweated thro' the Pores of Oak.*

DIALOGUE XIII.

*On the Use of the GEOCENTRIC PLANETARIUM
by Means of an Ephemeris.*

Cleonicus.

WE have now finished our Survey of the *Planetary System*, and I am well assured, my *Euphrosyne*, you understand the general *Phænomena* thereof very well; but something yet remains to be understood upon this Head, and I am willing to hope will give you as much Pleasure as any Part of our past Speculations, as it is of a practical Nature, and what you are to perform with your own Hands.

Euphros. I long to know what it is, *Cleonicus*, as every new Idea gives me new Delight.

Cleon. What I mean is what I sometime ago hinted to you, *viz.* That it is not enough for you to know the speculative Part of Astronomy, but also that you learn to find the Places and relative Aspects of the Planets, from an *EPHEMERIS*, for every Day of the Year.

Euphros. And do you think I am capable of doing this, *Cleonicus*?

Cleon. Yes, what should hinder you, when you are put into a proper Method for it?

Euphros. But I suppose I must first learn the Use of that Book, you call an *Ephemeris*.

Cleon. You must.—Here it is.—Look at it—

Euphros. It is but small indeed, but it is filled with such a Number of Characters, Figures, and Columns, that at first View I know not what to make of it.

Cleon.

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Cleon. That is every One's Case in a new Attempt ; when you consider each Article of the *Ephemeris* separately you will find it easy enough to understand.

Euphros. But first tell me why this little Book is called an *Ephemeris* ?

Cleon. Because it is a *Diary* or *daily Account* of the Motions or Places of the Planets, as they appear to the Eye placed both in the Sun, and at the Earth, throughout the Year.

Euphros. But why do you suppose the Eye to view the Planet from the Sun, since that is impossible ?

Cleon. Because on that Supposition you can observe or assign for any Time the *true Places* of the Planets in the Ecliptic ; and this *true Place seen from the Sun*, is called the *Heliocentric Place* of the Planets, for the Name of the Sun in *Greek* is *Helios*, but if the Planets are view'd from the Earth (call'd in *Greek*, *Ge*) then their Places and Motions are called *Geocentric*.

Euphros. I understand you, I believe, pretty well ; I see on the Right Hand Page, for every Month, a small Table with the Title of *The Heliocentric Motions* ; as there, on the Top, for the Month *December*, 1755.

The Heliocentric Motions.												
Days	♈	♉	♊	♋	♌	♍	♎	♏	♐	♑	♒	♓
1	29	26	4	22	24	33	9	3	29	6	18	40
6	29	35	4	45	27	0	14	8	7	0	16	51
11	29	45	5	8	29	27	19	13	14	54	11	7
16	29	54	5	30	1	53	24	18	22	48	1	47
21	00	3	5	53	4	17	29	24	0	42	19	41
26	00	12	6	16	6	40	4	30	8	36	5	38

Cleon. Very well, my *Euphrosyne*. You observe that Table divided in 7 Columns ; in the first is placed every 5th Day of the Month beginning with the first. On the Top of each of the other Columns, the Character of the Planet and of the Sign in which it is on the first Day of the Month ; and the Figures in the respective Columns shew the Place in *Degrees* and *Minutes* which the Planet is in, as seen from the Sun precisely at 12 o'Clock at Noon, on the several Days in the 1st Column ; for you must know, the *Astronomers* always begin their Day at Noon.

Euphros.

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Euphros. This is all so plain, that I can't but apprehend it; and thus, for Instance, on *December* the 1st, at 12 o'Clock, I observed the *Heliocentric* Place of *Saturn* (♄) is in $29^{\circ} : 26'$ of *Capricorn* (♑); of *Jupiter* (♃) in $4^{\circ} : 22'$ of *Libra* (♎); of *Mars* (♂) $24^{\circ} : 33'$ of *Gemini* (♊); of the *Earth* (♁) $9^{\circ} : 3'$ of *Gemini* (♊); of *Venus* (♀) in $29^{\circ} : 6'$ of *Sagittarius* (♐); and of *Mercury* (♂) in $18^{\circ} : 40'$ of *Cancer* (♋); and so for any other Day there specified.

Cleon. Very right, my *Euphrosyne*, I see there will be no Difficulty about the other Table of the *Geocentric Motions*, where the Place of the Sun and each Planet is given in their proper Columns, as viewed from the Earth, for every Day at Noon.—

Euphros. But besides these, there are several other Tables and Columns on the same Page; pray, what is their Use?

Cleon. We shall see that hereafter, Sister; the *Heliocentric* and *Geocentric* Motion will be sufficient at this Time to consider; and because we want to know constantly in what Part of the *Ecliptic* the Planets are, their *Geocentric Places* are shewn for every Day, as you see for the Month *December*.*

* Tables of the *Heliocentric* and *Geocentric Motions* or *Places* for *December* 1755, are here added from *Parker's Ephemeris*, lest the Reader should not have the said Book at Hand; and one Month only is sufficient for an Example of its Use.

TABLE

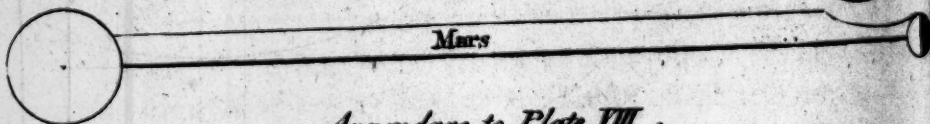
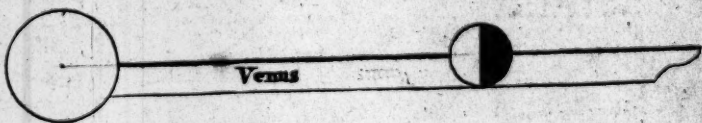
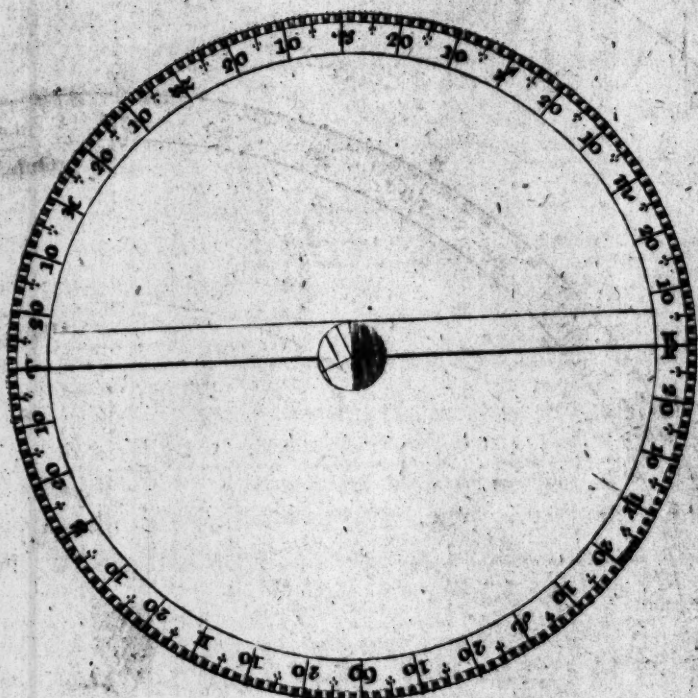
TABLE of GEOCENTRIC MOTIONS.

M D	☉	♈	♉	♊	♋	♌	♍	♎	♏	♐	♑	♒	♓	♈	♉	♊	♋	♌	♍	♎	♏	♐	♑	♒	♓
1	9	3	9	51	25	21	13	0	17	39	17	33	23	53											
2	10	4	25	3	25	26	13	10	17	30	18	48	23	44											
3	11	5	10	1	21	25	32	13	20	17	20	20	4	23	32										
4	12	6	25	33	25	38	13	29	17	9	21	19	23	D 44											
5	13	7	10	1	20	25	44	13	38	16	57	22	34	23	55										
6	14	8	24	59	25	50	13	47	16	44	23	50	24	19											
7	15	9	9	0	25	55	13	05	16	30	25	5	24	52											
8	16	10	22	30	26	1	14	6	16	15	26	20	25	32											
9	17	11	5	3	26	7	14	14	15	59	27	36	26	17											
10	18	12	18	9	26	14	14	23	15	43	28	51	27	8											
11	19	13	0	7	26	20	14	31	15	26	0	5	28	2											
12	20	14	12	32	26	26	14	40	15	9	1	22	29	1											
13	21	15	24	28	26	32	14	48	14	51	2	37	0	4											
14	22	16	6	8	19	46	39	14	57	14	32	3	52	1	11										
15	23	17	18	9	26	45	15	5	14	12	5	8	2	22											
16	24	18	0	11	1	26	51	15	13	13	52	6	23	3	37										
17	25	19	11	58	26	58	15	21	13	31	7	38	4	53											
18	26	21	24	0	27	4	15	29	13	10	8	53	6	10											
19	27	22	6	10	27	11	15	36	12	49	10	8	7	28											
20	28	23	18	27	27	17	15	44	12	27	11	24	8	47											
21	29	24	0	53	27	24	15	51	12	5	12	39	10	6											
22	29	25	13	29	27	30	15	58	11	42	13	54	11	28											
23	1	26	26	17	27	37	16	5	11	19	15	10	12	50											
24	2	27	9	17	27	44	16	12	10	55	16	25	14	15											
25	3	29	22	33	27	50	16	18	10	32	17	40	15	41											
26	4	30	6	7	27	57	16	25	10	8	18	56	17	9											
27	5	31	20	1	28	4	16	31	9	44	20	11	18	36											
28	6	32	4	15	28	10	16	37	9	20	21	26	20	4											
29	7	33	18	50	28	17	16	43	8	57	22	41	21	32											
30	8	35	3	39	28	24	16	50	8	33	23	57	23	1											
31	9	36	18	38	28	31	16	56	8	9	25	12	24	28											

Euphros. Well, let us not spend Time about Things so easy; I see that for every Day of the Month, the Places of the Sun and all the Planets are shewn in the Ecliptic, as they appear from the Earth; but pray, what depends on all this?

Cleon. A very pleasant *Astronomical Praxis*; by which you may at any Time be able to entertain yourself in a most rational and agreeable Manner, that is to say, you may in a Minute or two,





. Appendage to Plate VIII .

THE GEOCENTRIC PLANETARIUM.

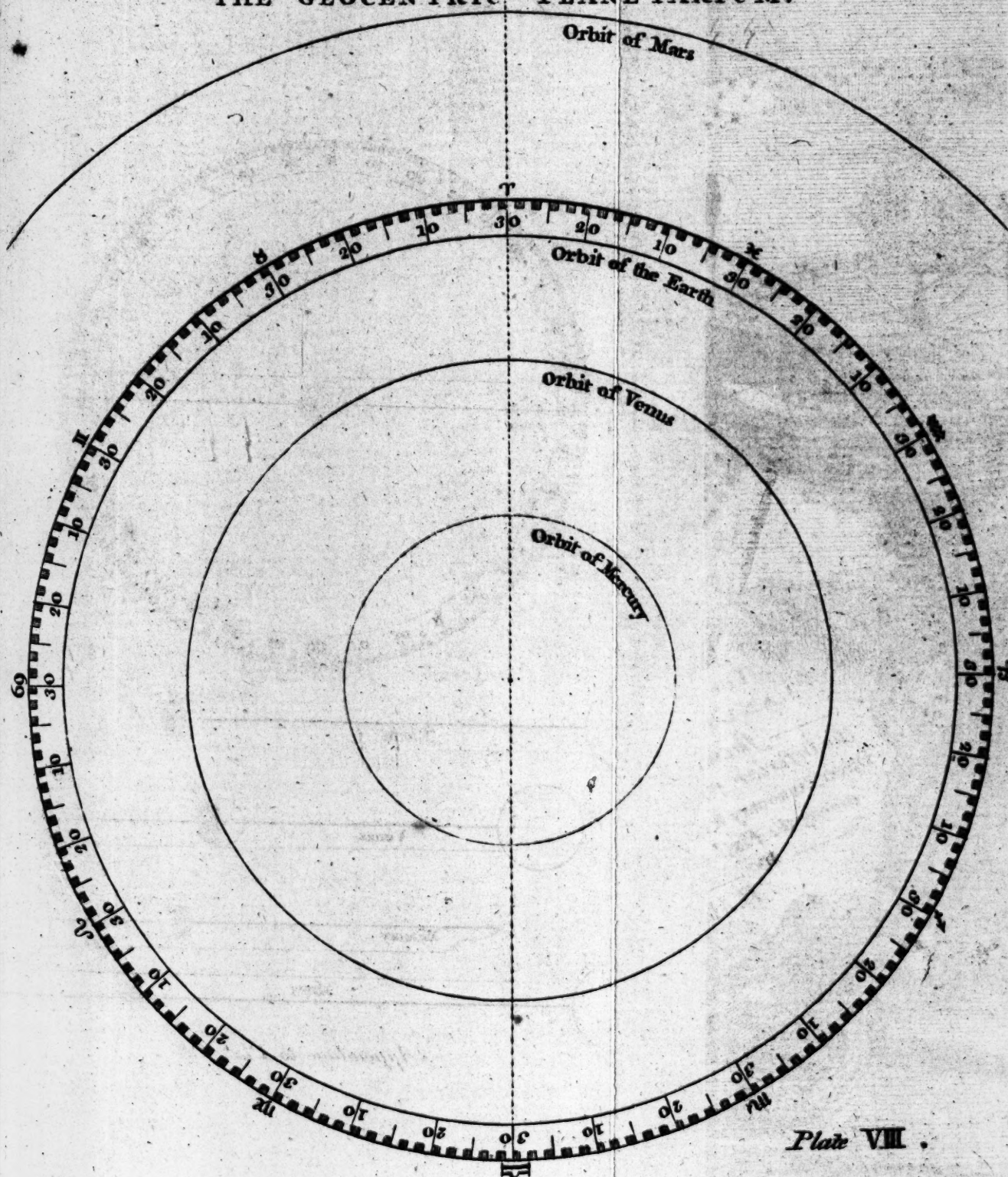


Plate VIII.



two, represent to your Self the true Appearance of the planetary System, just as it really is, in the Heavens for any Day you please; by assigning to every Planet its proper Place in its Orbit.

Euphros. This will be doing great Things indeed, *Cleonicus*; but how am I to go about it? I long to know ———

Cleon. For this Purpose, my *Euphrosyne*, I have prepared for you what I shall call a **GEOCENTRIC PLANETARIUM**, which you here see on this large Sheet of Pastboard, where you observe the Orbits of all the Planets are drawn at their proper Distances from the central Sun, in the same Proportion as in the System itself; and in the next Place, you see the Planets themselves all *moveable* in their Orbits, on *paper Labels*, about the Center of the Sun. Next, you see the Orbit of the Earth divided into its 12 Signs and Degrees, which we shall call the *Solar Ecliptic*; in this, the *True* or *Heliocentric Places* of the Planets are estimated. And, in the last Place, about the Earth you see a smaller Circle of the Signs, *moveable* about its Center, in which the Planets viewed from the Earth, must all appear, and which for that Reason I shall call the *Geocentric Ecliptic*.*

N

Euphros.

* I have added this Plate, with its Appendix, that such Gentlemen and Ladies as have not the Opportunity of a *real Planetarium*, may in a great Measure supply the Want of it by this *Geocentric Planetarium*, especially as something of this Kind has been always wanting to give Youth a Taste of the Pleasure of *practical Astronomy*.

In order then to prepare this Instrument for Use, you proceed in the following easy Method.

1. Cut the eighth Plate out of the Book, and past it on a Sheet of Card Past-Board.
2. Then with a Pair of drawing Compasses, make the Orbit of *Mars* a compleat Circle on the Past-board. Then cut out the Whole, of a circular Form, a little beyond the Orbit of *Mars*.
3. In the Appendix to this Plate, there are engraved the Labels of *Mercury*, *Venus*, the *Earth*, and *Mars*, which are to be cut out close to the black Lines; these, together with the Face of the Sun, are to be placed on the Center of the Planetarium on a String, by which they may be tied close down, yet freely *moveable* about the Center, so that the Center of the Planet on the Label may be always in the Orbit. Note, the Label of the Earth must be uppermost, and the Face of the Sun on that.
4. Cut out the *Geocentric Ecliptic*, so that it may consist only of the Circle of the Signs, and the Diameter between the black Lines; and let the Center of this be placed on a Thread through the Center of the Earth

Euphros. So far I understand you ; but I fear lest what is to come should prove a much greater Trial of Skill.——

Cleon. There is no Grounds of Fear to you, Sister ; if you attend to the following Precepts, every Thing will be easy.

First, observe in the Ephemeris the Heliocentric Place of each Planet, and bring the Label of the Planet to that Sign and Degree in the *Heliocentric Ecliptic*, that is, so that the Line which passes through the Center of the Planet may cut that Degree.

Secondly, Having done this for every Planet, fix them down to their proper Places in their Orbits by a *small Pin* through their Centers.

Thirdly, Bring the Earth to its Heliocentric Place, and fix the Label by a Pin passed through it into the Board.

Fourthly, The Geocentric Ecliptic is then to be moved about the Earth, and placed in such a Manner, that the Line of $\cap$ passing through the Earth's Center, may be parallel to or equally distant from the same Line of $\cap$ in the Solar Ecliptic, which you may easily do by the Eye.

Fifthly, This Geocentric Ecliptic so rectified, is to be fixed by a Pin through that Part of it which lies remote from the Sun.

Sixthly, Then in the last Place, strain a Thread over the Center of the Earth and each respective Planet, and that will cut the *Geocentric Ecliptic* in that Point where the Planet will appear to an Eye at the Earth. And thus, with a little Practice, you will be able immediately to exhibit the System of Planets, both as it is in it's Self, and as it appears to us at any Time.

Euphros. I make no Doubt but I shall understand these Precepts very well, when I join with them the Practice, in which you will assist me a little at first.

Cleon.

Earth on the Label, and tied down on it, so that it may freely move about the Earth's Center. Then is it fit to be used, as in the Dialogue above is directed.

5. To fit this Instrument for *Jupiter* and *Saturn*, it must be stuck on to the Side of a Room, or on a large round Table ; you must then lay a Thread over the Center of the Sun, and *Jupiter's* Place in the Ecliptic about the Sun, and at $12\frac{1}{2}$ Inches from the Center, stick a Patch, and it will be the true Place of *Jupiter*. For *Saturn* you do the same, but for him you must place the Patch at the Distance of $23\frac{1}{4}$ Inches. And indeed, in this Manner, Patches may be placed on the Orbit of the other Planets, if the Trouble of the Labels be thought too much.

Cleon. That I shall do in the next Place; therefore, to begin, take the Ephemeris and look in the Heliocentric Table for the Places of the Planets for the 26th Day of *December* next, and let me hear you say what they are for each Planet.

Euphros. I will — let me see, the Planet *Mercury* ☿ is in $5^{\circ} : 38'$ of *Scorpio*, (♏) and therefore, I suppose, I must take this Label of *Mercury* and bring the Edge of it to that Point of the Solar Ecliptic.—Well, here I fix it with a Pin, and what next, *Cleonicus*?

Cleon. You must now proceed to do the same with all the Rest; pray, where do you find the Planet *Venus* ♀?

Euphros. I find her Place to be in $8^{\circ} : 36'$ of *Aquarius* ♒, to which I bring her Ladyship, and pin her fast down. The next I must look for is the Earth—I see it—we are that Day in $4^{\circ} : 30'$ of *Cancer* ♋; thither I bring the Earth's Label, and fix it down with a Pin—so far I presume I am right, *Cleonicus*?

Cleon. You proceed very well; do the same by all the Rest, and you will erect a much better Scheme of the Heavens than any Astrologer could ever yet pretend to.

Euphros. The Place of *Mars* ♂ I see is in $6^{\circ} : 40'$ of *Cancer* ♋;—*Jupiter* ♃ is in $6^{\circ} : 16'$ of *Libra* ♎;—and *Saturn* ♄ is in $0^{\circ} : 12'$ of *Aquarius* ♒.—To these Places I have brought, and pinned down their Labels—And now, what Remains?

Cleon. Only to rectify the *Geocentric Ecliptic* —

Euphros. I know what you mean,—it is to place the Ecliptic about the Earth in a parallel Situation to that about the Sun—see, there it is done.

Cleon. With great Pleasure I see how readily you do it; you have now nothing more to do, but to lay a Thread from the Center of the Earth over the Centers of the several Planets; and you will then observe the Places in which they severally appear in the *Geocentric Ecliptic* are the same very nearly as those you see in the other Table for the *Geocentric Motions*.

Euphros. Indeed! that will give me great Pleasure—I'll try—I lay the Thread from the Earth over *Mercury*, and find it cuts the *Geocentric Ecliptic* in the 17° of ♐ *Sagittarius*—Now let me see the Table,—*Mercury's* Place is there $17^{\circ} : 9'$ of the same Sign.—I think I am very near the Matter, *Cleonicus*.

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Cleon. As near as you can desire or expect to be; for in *Instrumental Astronomy*, we must not stand for a few Minutes. Well, and where do you find *Venus*, my *Euphrosyne*?

Euphros. I will tell you presently — I lay the Thread tight over *Venus*, and it cuts the Geocentric Ecliptic in $18^{\circ} \frac{1}{2}$ of ♊ Capricorn — Now to the Table — Her Place is there $18^{\circ} : 56'$ — How! that is almost 19° — sure I am a little out here —

Cleon. Not at all, Sister; for unless the Degrees were very large, it is no Wonder if you mistake $\frac{1}{4}$ or $\frac{1}{2}$ a Degree now and then, it is enough, if by Instruments we come but nigh the Mark.

Euphros. Well, next for *Mars* — the String laid over that Planet cuts the Ecliptic in 10° of ♋ — in the Table I see it is $10^{\circ} : 8'$ — pretty near. — I next extend the String to *Jupiter's* Center, and it cuts — let me see — $15^{\circ} \frac{1}{2}$ of ♌ ; — in the Table, that Planet seen from the Earth, is in $16^{\circ} : 25'$ of ♌ — I am near the Truth here also. — In the last Place, let me try for yonder Planet *Saturn* — I lay the Thread over his Center, and it cuts the Ecliptic in 28° of ♍ ; — in the Table it is $27^{\circ} : 57'$, within $3'$ of the Truth.

Cleon. By this *Praxis*, you see, my *Euphrosyne*, how nearly the Instrument and the Table agree; and how easy it is in this Manner to represent the Situations and Aspects of the Planets for any other Time. The Reverse of this Process is also very easy, viz. to find the Heliocentric or true Places of the several Planets in their respective Orbits, by laying a Thread from the Earth's Center to their apparent or Geocentric Places; for the Thread so extended will always cut the Orbit of the Planet in the Place where it really is at that Time.

Euphros. It is much easier than I thought it was, and will often be the subject of my leisure Hours Amusement. — But as you mentioned the *Aspects* of the Planets, I should be glad to know what is meant by the *Lunar Aspects*, and *Aspects* at the *Earth*, in a Table for every Day under the Heliocentric Motions.

Cleon. Those Tables of Aspects are of no great Importance; they only shew us how the Planets are posited with Respect to the Moon in one Table, and with Respect to each other, as seen from the Earth, in the other. And they use the Symbol Δ for the *Trine Aspect*, that is, when the Planets are a third Part of the Ecliptic distant from one another, viz. 4 Signs; if they are but

but 3 Signs apart, that Aspect is called *Quartile*, denoted by $\square$; if but 2 Signs from each other, it is called a *Sextile*, and is shewn by this Mark $*$; if they are in *Conjunction*, it is shewn by δ ; and if in *Opposition* by γ . And the Number placed by the Symbol, shews the Hour after Noon, when that Aspect happens.

Euphros. I believe I understand all that you have said, *Cleonicus*; but let me try if I can make it out by Experiment.

	The Lunar Aspects.						Aspects at the Earth.
	$\odot$	η	γ	δ	γ	δ	
1				$\Delta 11$		$\delta 22$	D Perig.
2		$* 0$					
3	$\delta 1$		$* 5$		$\delta 17$		
4			$\square 6$	$\delta 11$		$* 23$	$* \odot \gamma$
5		$\delta 1$					
6							
7	$\odot * 11$		$\Delta 9$				$* \eta \delta$
8				$* 8$	$\square 6$		
9				$\Delta 20$			
10	$\square 0$	$* 16$			$\square 28$	$\Delta 18$	$\square \gamma \delta$
11							
12	$\Delta 6$		$\delta 5$	$\square 6$			
13		$\square$			$\Delta 18$		D Apog.
14	$\odot$			$* 18$			
15		$\Delta 18$					
16						$\delta 8$	
17			$\Delta 6$				
18	$\delta 5$						
19			$\square 18$	$\delta 13$	$\delta 8$		$\delta \delta \gamma$
20		$\delta 18$				$\Delta 18$	
21	$\odot$						
22			$* 6$				
23	$\Delta 10$						
24				$* 3$	$\Delta 13$	$\square 9$	
25	$\square 21$	$\Delta 11$					$* \gamma \delta$
26			$\delta 18$	$\square 7$		$* 19$	
27		$\square 14$			$\square 0$		
28	$\odot * 4$			$\Delta 10$			D Perig. $\delta \odot \delta$
29		$* 5$			$* 7$		
30			$* 21$				
31						$\delta 10$	

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I observe against the 26th of *December* (to use the same Example as before) in the Column under *Jupiter* ♃ there is placed 6 18, which I apprehend denotes the Planet is in *Conjunction* with the *Moon* at 18 Hours after Noon—But now, as there are but 12 Hours from Noon to *Midnight*, pray, what am I to understand by the 18th Hour, *Cleonicus*?

Cleon. Why you are to reckon 18 Hours from Noon of the 26th; 12 of which will bring you to *Midnight*, and the other 6 will make 6 o'Clock in the Morning of the following Day; so that the *Conjunction* happens on the 27th of *December* at 6 in the Morning.

Euphros. Poh, that I could not think on so easy a Thing as that—well, what is the next *Lunar Aspect* that I see against the same Day—it is ☐ 7, in the Column of ♄, by which I see *Mars* will be in its *Quartile Aspect* with the *Moon*, or 4 Signs from her, at 7 o'Clock that Night—Again: I see in the Column of ♀, the Aspect * 19, shewing *Mercury* to be in *Sextile* with the *Moon*, at—let me think—19 is equal to 12 and 7—Oh, at 7 o'Clock the next Day.

Cleon. Very right; one Example more of the *Aspects* at the *Earth* will make you a perfect Mistress of this Part of the Science of the Stars.

Euphros. That gives me no Trouble; for against the 25th Day, I see the Characters * ♃ ♄, which shew that *Jupiter* ♃ and *Mercury* ♄ seen from the *Earth*, have a *Sextile Aspect* *, or are two Signs distant from each other.

Cleon. Very well; and this you see confirmed by the *Geocentric Planetarium*, and also by the Table of *Geocentric Motions*, for the Place of ♃ is there 26° : 18' of *Libra* ♎, and the Place of *Mercury* is 15° : 41' of ♐ *Sagittarius*, which is near 2 Signs or 60 Degrees from the other. And as you are now ready in the Use of the *Ephemeris*, and can find the Places and Aspects of the Planets for any given Day, as they are seen, both from the Sun and *Earth*, we may proceed to the Use of the *Stellated Planetarium*, which is somewhat different from what you have yet seen, and this shall be the Subject of the next Conversation.

D I A.

DIALOGUE XIV.

On the Use of the STELLATED PLANETARIUM.

Euphrosyne.

SINCE I last saw the *Planetarium*, I observe you have made an Addition to it; pray, what means that Hoop about it, with so many small Stars?

Cleon. That is to answer the Purpose I have often mentioned to you, of shewing more plainly and directly the Manner in which the Planets must necessarily appear to us to go *forwards and backwards*, and at Times be Stationary, among the Stars in that Part of the Heavens thro' which they pass; which Stars are those engraved on the Hoop, and this *stellated Zone* will therefore fitly represent the *artificial ZODIAC* of the Planets.

Euphros. You have indeed often promised me the Pleasure of those Appearances in this Way, which I presume will be more natural than those in which I have already viewed them. But I observe, you have only the three Planets next the Sun, in the Planetarium now.

Cleon. They will be sufficient for the present; and you will take Notice that the *Wire* which passes from the Earth thro' the Planet *Mercury* to the *starry Zodiac*, does represent a *Ray of Light*, by which the Planet is seen by the Eye; and as the Planet moves on the Instrument it will point out the apparent Place of the Planet among the Stars, just as a Ray of Light shews the apparent Place of the real Planet in the Heavens.

Euphros. I see the Congruity of such a Representation; and I farther observe, you have placed these three Planets at their proper or proportional Distances from the Center of the Sun.

Cleon. I have placed them at their true Distances that you may see the Times employed in their *direct and retrograde Motions*, and their *stationary Aspects* are the very same in the Planetarium as in the Heavens, or in the *Ephemeris*, where the said Motions are all minuted down very punctually.

Euphros. I shall be pleased with repeating this *astronomical Praxis* in a different Way from that of the *Geocentric Planetarium*,
though

though that delighted me much ; especially as I apprehend this will be more natural, and perfect : But as the *Ephemeris* will be necessary I will go and fetch it ——— Here it is, *Cleonicus*, how are we to proceed with it ?

Cleon. I will tell you ——— give me the Book ——— let us now propose to find when the Planet *Mercury* next begins to appear *direct* in Motion, when *stationary*, and when *retrograde* ; and how long a Time each of these *Phænomena* will take up.

Euphros. This will be very entertaining ; but, pray, will it not be required to find the true Places of the Earth and the Planet for this Purpose ?

Cleon. It will, and that you can easily do for any given Time ; now the Time when every Planet begins to appear *direct* in Motion, is marked with the Letter D, and when *retrograde*, with the Letter R ; and therefore may be easily observed at any Time, and shewed by the *Stellated Planetarium*.

Euphros. Well, I long to try the little Skill I have in a Solution of this Problem. The Planet *Mercury* I see you propose for the Subject, but which *Ephemeris* must I use for this Purpose, this for the old Year 1755, or must we have one for the present new Year 1756 ?

Cleon. It will be best to make use of both, because the Planet *Mercury* begins to be *direct* in Motion the 4th Day of *December* 1755, as there you see in the Table, in the Column for *Mercury*.

Euphros. I do ——— I see the Letter D placed there, to denote it — It is then in the $23^{\circ} 44'$ of *Scorpio* $\cap$, seen from the Earth.

Cleon. Very good, my *Euphrosyne*. Now let us place the Earth upon its proper Stem or Arm, and just over the 24th Day of *December*, 1755 ; and you observe a fine long moveable Wire in the middle Part of its Surface. ———

Euphros. I do. ——— But what Purpose is that Wire to answer ?

Cleon. It will pass through the Body of the Planet *Mercury*, when placed on its Arm, and its End will constantly pass by and among the fixed Stars on the Hoop or *Zodiac* ; and so it will represent the *Ray of Light*, by which the Planet is seen by us, and by which its *apparent Motions* will be determined and shewn among the Stars in the Heavens just as they appear to us.

Euphros.

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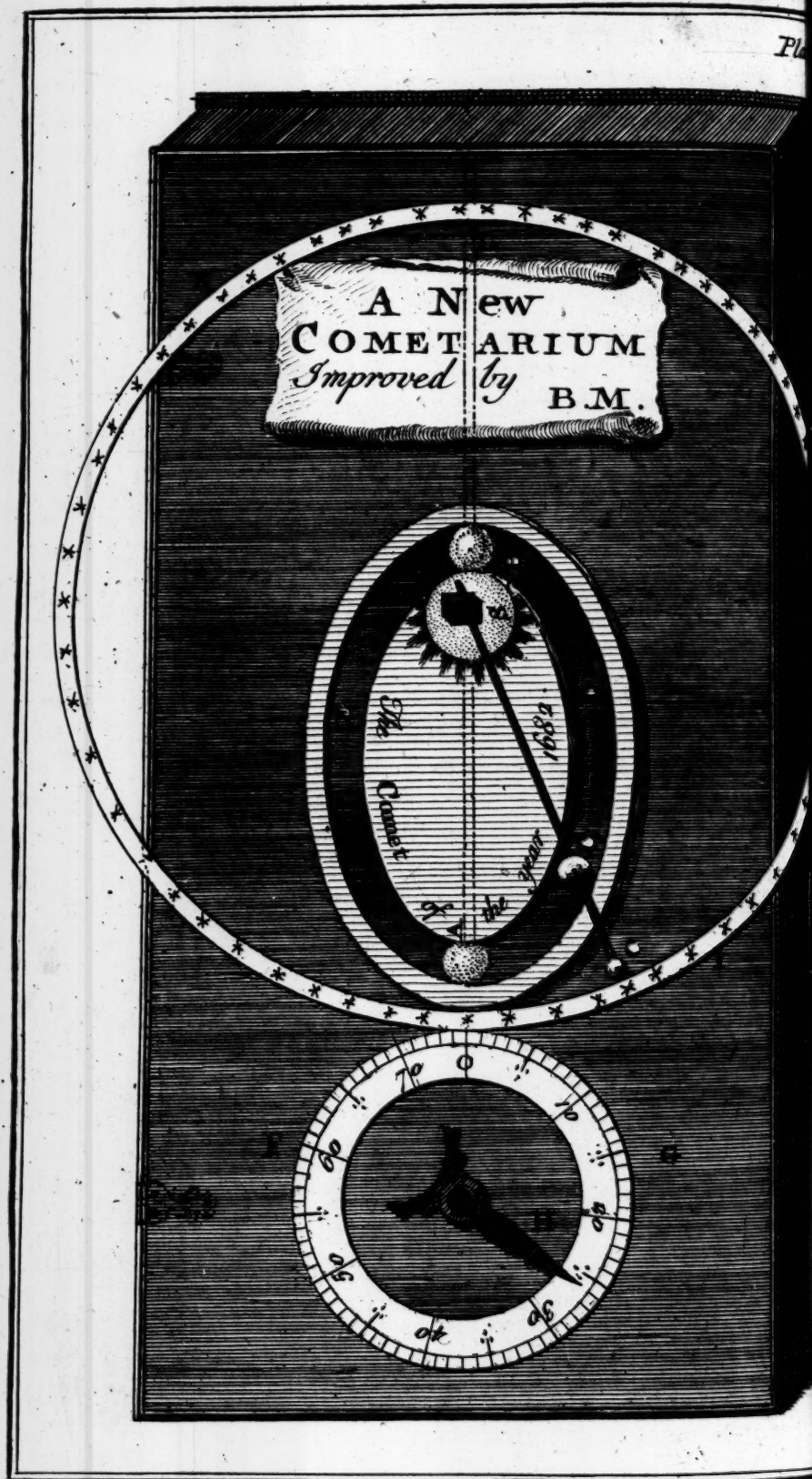
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Euphros. Well, I long to see the Machine in Motion. — But do you not place the Planet *Mercury* also in that Part of the Ecliptic, which it really possesses at that Time?

Cleon. Yes, or else we do Nothing: — But in order to do that rightly, you will observe, that in the Table of *Heliocentric Motions* (Page 86) the Planet's Place for the first Day was in $18^{\circ} 40'$ of φ , and on the 6th Day in $16^{\circ} 51'$ of *Leo* Ω ; therefore in five Days the Planet moved $28^{\circ} 11'$; one fifth Part of which is $5^{\circ} 40'$, the Motion in one Day; in two Days therefore it moved thro' $11^{\circ} 20'$, which subducted from $16^{\circ} 51'$ leaves $5^{\circ} 31'$ of *Leo* Ω , for its Place on *December* the 4th, 1755, when it began to be direct in Motion; and of Course to that Part of the Ecliptic the Arm which carries *Mercury* must be set, which you see I have done. — Next I pass the Wire thro' the Body of *Mercury*. — and then I place the Planet on its Stem — lastly, I fix a small, white, shining Bead on the End of the Wire by the Stars. — And thus the *Planetarium* is rectified for our Purpose. — You now observe the *Earth*, *Mercury* and *Venus* all in Motion.

Euphros. I do; the Planet *Mercury* goes the same Way with the *Earth*, from West to East — The white Bead also moves among the Stars the same Way.

Cleon. Very well, Sister; and you will see the Planet, and its representative Bead both keep moving the same Way for a considerable Time. — You will observe it thro' all the present Month *December*. — Let us now take the new *Ephemeris* for the Year 1756, and you will see the Bead keep moving on the same Way thro' all *January*. — Now take the Book, and as there will be Time enough, let me see you find the Day when the Planet begins to be *Retrograde*.

Euphros. I shall see that soon — let me look in *February* — I see no Letter R there — Next, let me look at *March* — Oh, there I have it, against the 2d Day I see the Letter R of *Retrogradation*. — Hence I observe the Planet is direct in Motion from *December* 4, 1755, to *February* 2, 1756.

Cleon. Admirably good, Sister; and now attend to the Planet in the Machine. — The *Earth* and the two Planets still keep moving forward; — but *Mercury's* Representative among the

Stars begins to slacken its Motion — do you not observe a sensible Difference between it and the Planet itself, my *Euphrasyme*?

Euphros. Yes, indeed, I do; and it is very pretty and pleasant to behold it. — Let me look, what Day the Earth is upon — The 11th of *February* — very well; now let me see the new Year's *Ephemeris* — How much do I find it there move from the 11th to the 12th? — about $2\frac{1}{2}$ Degrees, and that is not half so fast as its true Motion — it now moves slower, — now very slow indeed — not one Degree in a Day, — it is now the 23d of *February*; — It scarcely now moves at all — there it is quite at Rest — the Earth is now upon *March* the 1st; — Well, and in the *Ephemeris*, *March* the 2d shews it begins to be *retrograde* by the Mark R. — All this is wonderfully natural, instructive, and entertaining, beyond any Thing of this Sort that I have seen before.

Cleon. It is not strange the Phenomenon this Way shewn should please you so much; because it is so natural as to be the very Thing itself. You'll see by the *Ephemeris*, that the Planet is really not *Stationary* at all, but only in Appearance; and that as soon as the Bead ceases to move forwards, it begins to move backwards.

Euphros. I do; for I observe that from *February* 29 to *March* the 1st, it moved two Minutes of a Degree forwards, but from the 1st to the 2d of *March*, it moved 6 Minutes back again. — Whence I learn that the Planets are (as you say) *stationary* only in Appearance, and that arising from the Motion being insensibly slow a few Days only. — But behold, it is now going backwards — Good Heavens, how fast it moves! — 'twill not be long e'er it gets quite back again. — How very swift the Motion, and short the Time of its Retrogradation — Why, before the Month is out, it stops again — it moves no longer. — The Earth is now at *March* the 25th — The Letter D is there too, in the *Ephemeris* — How exact is the Agreement between the *Book*, the *Planetarium*, and the *System* itself? — The same Things appear in all, and force themselves upon the Understanding, at the same Time they fill the Mind with the most sublime and rational Pleasures.

Cleon. The *retrograde Motion* in *Mercury* is but of short Duration indeed, as in the present Case no more than 23 Days; whereas

whereas he continues *direct* in Motion about 90 Days, which is more than three Times as long. And in the same Manner we might shew the direct and retrograde Motions of *Venus*, or any of the other Planets; for the superior Planets, *Mars*, *Jupiter* and *Saturn*, may be placed on this *Stellated Planetarium* in their true Proportion of Distances, and then the Times of their appearing direct and retrograde among the Stars on the Instrument, will be the same to a Day as we observe them in the Heavens. But we must at present desist from a farther Speculation of the Planets, and leave what remains till you are a little more prepared for *astronomical Calculations*, and the Use of Tables for that Purpose.

DIALOGUE XV.

Of the COMETS.

Euphrosyne.

YOU have, dear *Cleonicus*, obliged me with a long and particular Account of the six *primary Planets*, as they are called, which constitute the most considerable Part of the Solar System. But what succeeds to these? When we are arrived to the out-most Bounds of the System, where go we then?

Cleon. Where go we! much farther, my *Euphrosyne*, than we have yet been.

Euphros. What, to the Stars, I suppose.

Cleon. No, no; now you over shoot the Mark; we must take a much longer Time to travel thither.

Euphros. It can't be the Moon, for we left her far behind, hovering about the Earth. But hold—I recollect—'tis the Comets we next survey; did you not intimate thus, *Cleonicus*? when we last conversed together.

Cleon. Yes, I did; the Comets next present themselves as the Subject of our Speculation.

Euphros. Pray, what is a Comet?

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Cleon. A Comet is what the common People call a *Blazing Star*, because it appears like a large Star with a long Tail, *blazing* as it were, or streaming from it. It is a very extraordinary and amazing Sight, and is thus finely described by *Mr. Baker*.

*At his Command, affrighting human Kind,
Comets drag on their blazing Lengths behind:
Nor, as we think, do they at Random rove,
But in determin'd Times, thro' long Ellipses move;
And tho' sometimes they near approach the Sun,
Sometimes beyond our System's Orbit run,
Throughout their Race they act their Maker's Will,
His Power declare, his Purposes fulfil.*

Thus also *Virgil*:

*The threat'ning Comets, when by Night they rise,
Shoot sanguine Streams and sadden all the Skies.*

Euphros. Did you ever see a Comet, *Cleonicus*?

Cleon. Yes; but they very rarely appear; and tho' they are many in Number, yet their long Periods render their Return but seldom, and therefore a Comet can't be often seen.

Euphros. How long is it since the last Comet appeared?

Cleon. The last we saw here in *England*, was in the Winter of the Year 1743, but mention is made by Foreigners of others appearing so late as 1748.

Euphros. You say the Comets are many in Number, pray, can you tell how many?

Cleon. No; all those which have been duly observed, and fallen under the Notice of Astronomers, are about 39; tho' 'tis possible, if not probable, there are, belonging to this System, many more.

Euphros. But I want to know what a Comet is, or what it is that makes the Appearance of a Star and its blazing Tail?

Cleon. They are supposed to consist of a very solid, compact and durable Substance, capable of the greatest Degree of Heat and Cold without Dissolution; and of an opaque Nature, shining only by Reflection of the Sun Beams, like other Planets.

Euphros.

Euphros. By that you intimate the Comets to be a Kind of Planets.

Cleon. They are most certainly so ; for they move in stated Periods of Time about the Sun ; of which Periods, some are longer, some shorter, as in the other Planets.

Euphros. Are the Times of the Periods of these Cometary Planets known by Astronomers, like those of the other ?

Cleon. No, but of some few only ; as that which appeared in 1680 hath its Period in 575 Years ; that in 1661, has its Period in 129 Years ; and that of 1682 has its Period the shortest of all, viz. $75\frac{1}{2}$ Years. So that the shortest Period of the Comets is much longer than the longest Period of the Planets.

Euphros. Well, but if this last Comet's Period be but $75\frac{1}{2}$ Years, and he appeared in the Year 1682, it must be expected that he will again appear in the Year 1758 ; What say you, *Cleonicus* ?

Cleon. Say, 'tis true, it will undoubtedly then appear, to the great Pleasure and Surprize of all the curious Part of Mankind.

Euphros. I hope, as the Time is so near, we shall both live to see so extraordinary a Phænomenon.

Cleon. I hope so too ; I should scarce regret Death so much on any worldly Account as preventing me of so desirable a Sight.

Euphros. In what Kind of Orbits do the Comets move about the Sun ?

Cleon. In such as are of an oval or elliptical Form, like that of which you saw a Part in the Plate of the solar System.

Euphros. Here is the Plate you mention, — I see the Orbit and the Comet in it : The Sun is very near to one End of it, I see, and the two Sides of the Orbit of the Comet runs out far beyond the Planetary System.

Cleon. Yes, and so it is in Truth ; the Comets in one Part of their Orbits approach extremely near the Sun ; and in another, are immensely distant from him. In short, they come nearer to, and go farther from the Sun, than any of the Planets by much.

Euphros. Why then they must needs be sometimes much hotter than *Mercury* ; and at other Times much colder than *Saturn* ;

turn; for I presume, they have no Heat but what they receive from the Sun.

Cleon. They have not; and therefore they have the greatest Extremities of Heat and Cold by Turns; for when they are in that Part of their Orbit nearest the Sun, they conceive a prodigious Degree of Heat, which gradually diminishes as they recede from the Sun, and till becoming cold, that Coldness gradually increases to an Extremity proportional to the Distance they go from the Sun?

Euphros. Pray, can Astronomers tell the nearest and greatest Distance of Comets from the Sun?

Cleon. Of some few they can pretty nearly; particularly that Comet in 1680 came so near the Sun, that it was not a sixth Part of the Sun's Diameter distant from his Surface; and therefore, its Heat must then be *two thousand Times hotter than red hot Iron*. And from thence it took its Course from the Sun to the Distance of above *11 Thousand Millions of Miles*, which is at least 14 Times farther than the Orbit of *Saturn*, the Boundary of the Planetary System. — The *Light and Heat* therefore of that Comet is then near *two Hundred Times* less than at *Saturn*, and above *17 Thousand Times* less than with us; thus the *Light and Heat* of *Saturn* is much more intense, compared with the Comets, than ours in Comparison of *Saturn's*.

Euphros. Oh! *Cleonicus*, were it not for the Power of Numbers, we could never be able to form Ideas of such extreme Degrees of Cold and Heat! for its Heat, I suppose, if compared with ours, is as surprising. —

Cleon. And much more so: For being, when nearest the Sun, about *one Hundred sixty seven Times* nearer the Sun than the Earth, and *sixty five Times* nearer than *Mercury* itself: the *Light and Heat* therefore, at that Time at the Comet must be at least *four Thousand Times* greater than in *Mercury*; and no less than *twenty eight Thousand Times* greater than in our *torrid Zone*. What think you of that?

Euphros. Think! what should a Woman pretend to think of such Matters, as I believe I may venture to say, surpasses the most philosophical Heads; and which they can give no just Account of? Or, am I mistaken, *Cleonicus*?

Cleon.

Cleon. Very little; for though it be possible to produce a small circular Spot of Heat by Means of a burning Glass, that shall have a Degree of *Ardour* equal to that at the Comet; that this Spot can bear no Proportion to the glowing Globe of the Comet in Point of *Heat*, than it does, perhaps, in Magnitude, which is infinitely small.

Euphros. Can you tell any Thing of the Magnitude of a Comet, *Cleonicus*?

Cleon. I do not remember that there is any certain Mensuration of the Comet; tho' there is sufficient Reason to believe that they are some less, some equal to, and some bigger than the Moon; for they are but small, and it is their Tail that makes them so conspicuous.

Euphros. But, pray, what is that you call the Tail of the Comet?

Cleon. It is a prodigious Quantity of Fume and Vapour flying off from the Body of the Comet, as it becomes more and more heated in its Approach to the Sun.

Euphros. No Wonder there should be such an Evaporation, considering how so cold a Body is gradually so intensely heated; What Particulars do you observe of a Comet's Tail?

Cleon. The following. (1.) They seem largest and most splendid immediately after they return from the Sun; because being then hottest they emit the greatest Quantity of Vapours. (2.) The Tail lies always towards those Parts, which the Body of the Comet leaves in its Descent; which is agreeable to the Nature of Smoke and Vapour. (3.) They appear broader on their upper Part than near the Head of the Comet; as all Vapours, the higher they rise the more they dilate themselves. (4.) The fixed Stars are often seen through the Tails of Comets; which prove they consist of a very fine and pellucid Vapour. (5.) The Tails of Comets are extremely long; some having been computed to be not less than eighty Millions of Miles in Length.

Euphros. Well, Nothing would more delight me, than to have but a probable Use of those Prodigies of Nature assigned! Can you say, *Cleonicus*, to what End the Almighty has appointed those wondrous Bodies.

Cleon. No, I can scarce conjecture at it; the Ancients (who were entirely ignorant of their Nature) esteemed them a Sort of

of Meteors kindled in the Air, and portending some extraordinary Event. As *Hudibras* merrily expresses it. —

*Portending Blood like blazing Star,
The Beacon of approaching War.*

Or, thus more seriously, *Homer*. —

*As the red Comet from Saturnius sent
To fright the Nations with a dire Portent,
(A fatal Sign to Armies on the Plain,
Or trembling Sailors on the wat'ry Main)
With sweeping Glories glides along in Air,
And shakes the Sparkles from his blazing Hair.*

Euphras. I do not much regard the Opinion of the Ancients; Pray, what do the Moderns, and the most judicious among them, take the Comets to be?

Cleon. Some, (and not a few) think they are appointed as the Places of Torment for the damned; that is, that each Comet is, properly and literally speaking, a *Hell*; from the intolerable and inconceivable Heat and Cold which is found alternately in those Bodies. To this agrees the Poet.

*Who can the Comet's wondrous Journey tell;
Seats not unaptly deem'd the Place of Hell.
Now burning in the Sun's immediate Beams;
More frigid now than Greenland's frozen Streams.
Of all God's Works, our Reason Nothing shows,
So fitly form'd for Torments and for Woes.*

Euphras. O dreadful, *Cleonicus*! What, every Comet a *Hell*! Surely the Philosophers begin to preach very terrible Doctrine indeed; how will such receive a *Plurality of Hells*, who can scarce think it consistent with the Goodness and Mercy of God to appoint any *Hell* at all!

Cleon. You must consider, Sister, that what is said on this Head, is Nothing but Conjecture; there are some other Uses assigned to Comets, which to some Philosophers appear very probable.

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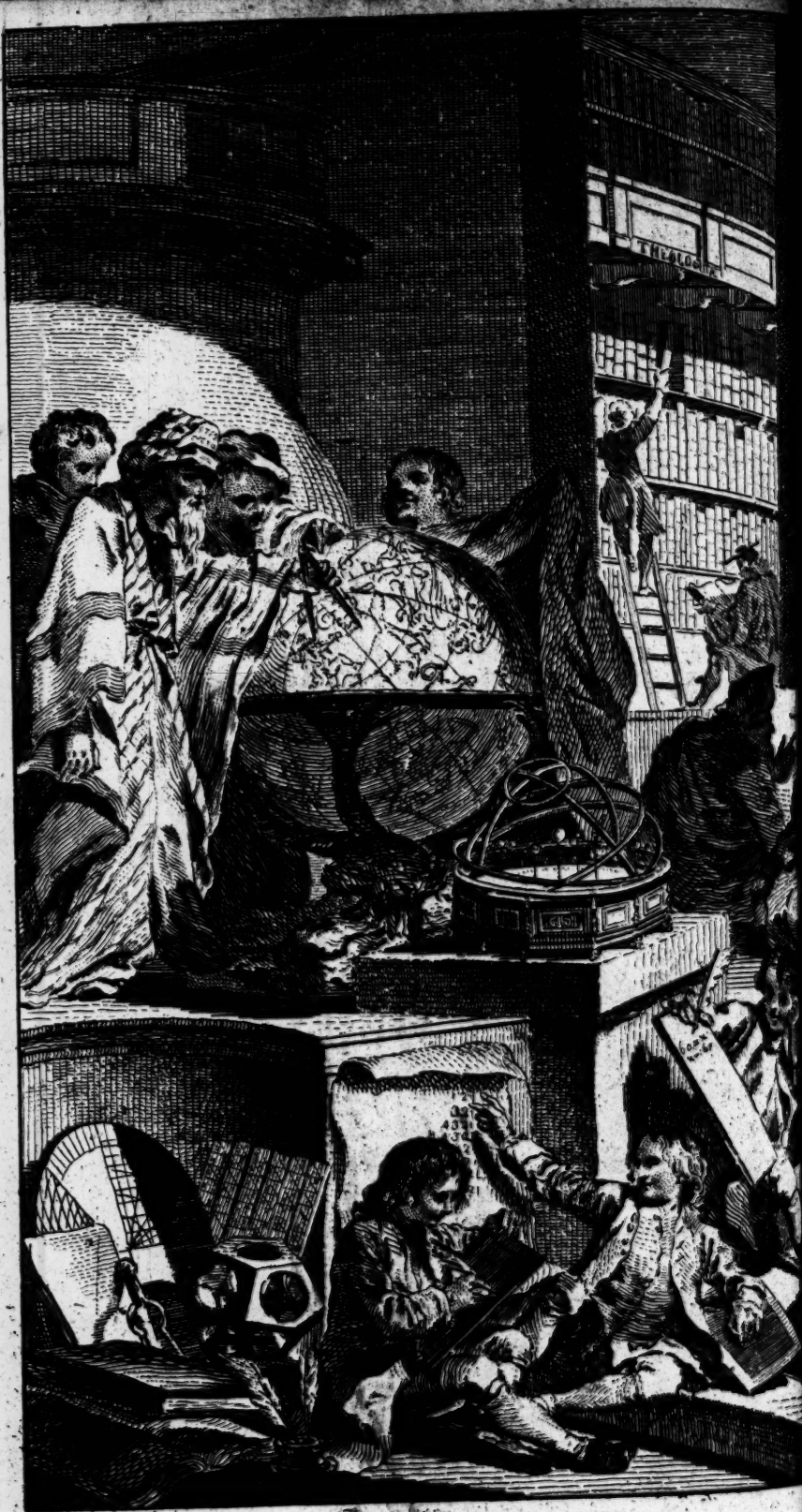
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W. Owen del. J. B. Del. sculp.

Engraved for the General Magazine of Arts & Sciences for W. Owen at Temple

Euphros. What are they?

Cleon. Some suppose, that they are the Means appointed by the Almighty for putting a Period to the Planetary World; either by involving the Globe of the Planets in their Atmosphere of Water, in their Return from the cold Regions, and so drown them by a general Deluge or Flood, as was the Case, according to some, of our Earth in the Time of *Noah*.

Euphros. Hold: Pray answer me a Question, which I can scarce ask without trembling; Do the Comets indeed pass and repass in their Orbits so near the Orbit of the Earth, as to endanger it in the Manner you represent by their near Approach? If so, then we are not only liable to be drowned on one Hand, but burnt to Death on the other; if the Comet should take us in his Return from the Sun.

Cleon. Indeed, my *Euphrosyne*, the Case seems to be very much so; it has been shewn that the Comets of the Year 1618, and 1684, came very near the Earth's Orbit; and particularly that of 1680, *Nov. 11.* at one o'Clock in the Afternoon was at so small a Distance, that had the Earth been about that Part of its Orbit, God only knows what the Consequences might have been of so near an Appulse of so terrible a Body! If a Comet should thus encounter the Earth at its Return from the Sun a little too nearly, it would undoubtedly consume the Earth, and all its Inhabitants, as so many Moths; it might convert the Matter of the present Earth into a different Kind of Substance, and render it an Habitation fit for Beings of a quite different Nature from ours.

Euphros. Upon my Word, *Cleonicus*, you have made me almost afraid to live upon the Earth. As the besieged in a Town expect and fear the dire Approach, and Fall of Bombs, so the Inhabitants of the Earth may fear the sudden, dreadful Shock of Comets, and expect one Day or other to have the Globe dashed to Pieces about their Ears, and themselves absorbed in an Abyss of Water or Fire!

Cleon. Be not dismayed, *Euphrosyne*; these are great, but rare Events; for, though they are possible in Nature, yet some Things make it a very great Chance if they happen at all with regard to any definite Time. For the Plains of all the Comets Orbits are raised above those of the Planets; so that there is but one particular Place in the Orbit of a Comet where its Tail can pass

over the Orbits of the Planets; and it is so many Chances to one, that a Planet happens to be in that Part of its Orbit at that particular Time, that we have no Reason to fear any such Catastrophe: And they, who have talked about such terrible Things, may be rather said to have *dreamed*, than demonstrated any such future Events.

Euphros. But pray, *Cleonicus*, can you assign any more innocent and less terrifying Uses of Comets, than those you have mentioned?

Cleon. Yes; some Philosophers, and those of the first Rank, imagine, that, by the Rarefaction and spreading of the Vapours of the Tails of Comets, they supply the Planets with Moisture, which they suppose continually decreases by Vegetation, Putrefaction, &c. They also farther suppose, that Comets, in their several Revolutions, approach nearer and nearer to the Sun, till at last they fall into, and supply the Sun with fresh Fuel, Fire, and Heat. But how Comets should do this, without they consist of a very combustible Matter, of a much larger Bulk, and made much quicker Returns, is not very easy to conceive. And thus I have told you, as much as is generally known of the Comets; and shall at present conclude with Mr. *Baker's* Description of a Comet in the following Lines.

*At his Command, affrighting human Kind,
COMETS drag on their blazing Lengths behind:
Nor, as we think, do they at Random rove,
But, in determin'd Times through long Ellipses move.
And though sometimes they near approach the Sun,
Sometimes beyond our System's Orbit run;
Throughout their Race they act their Maker's Will,
His Power declare, his Purposes fullfil.*

Universe, Page 19.

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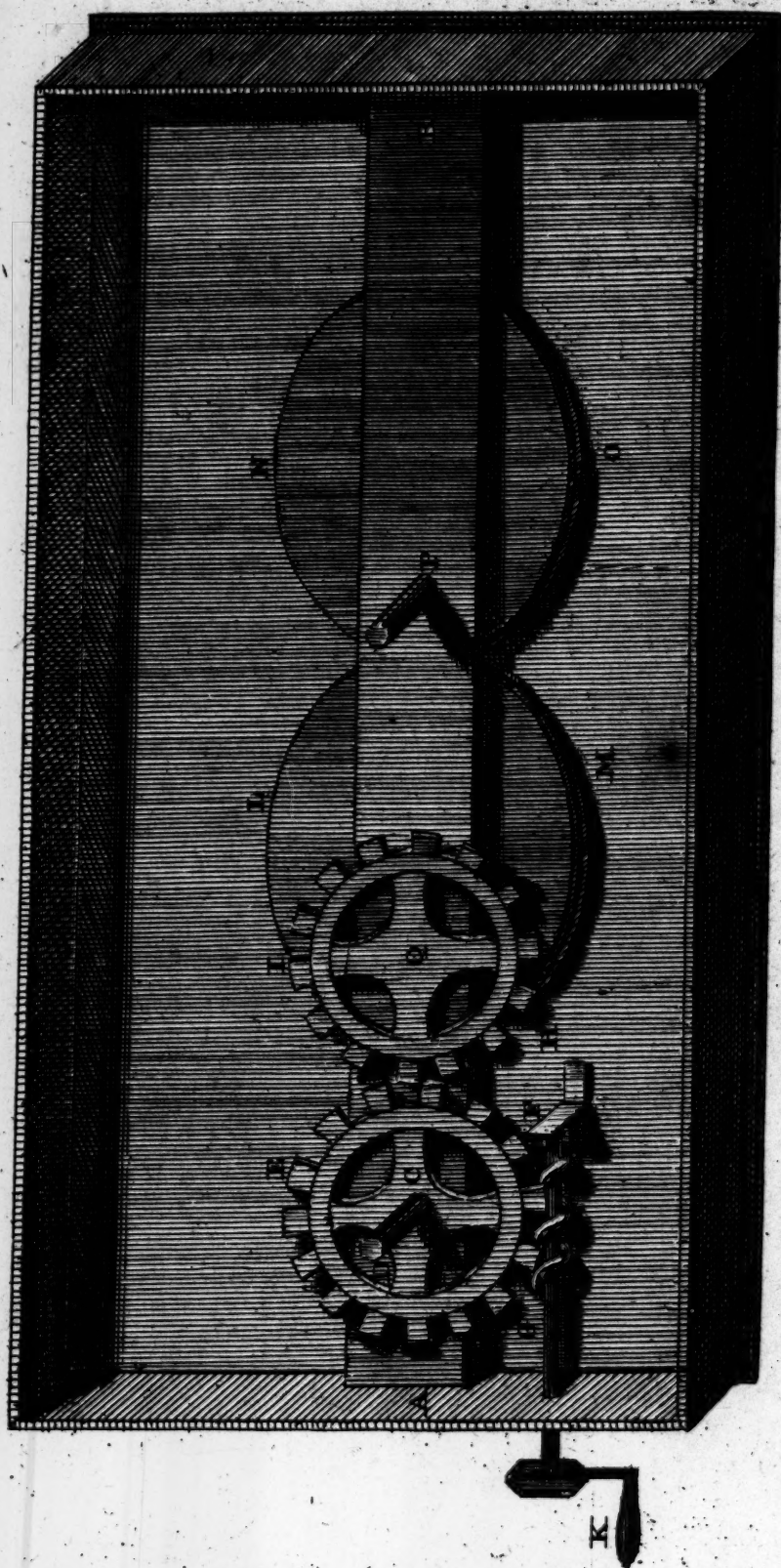
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Plate XI.
A View of the Wheel-work of the COMETARIUM.



DIALOGUE XVI.

On the Use of the COMETARIUM.

Euphrosyne.

SINCE you gave me the Lecture on Comets, you have filled my Head with such odd kind of Ideas, that I scarcely know whether I hope or fear most to see a Comet; but dear *Cleonicus*, since that is shortly to be the Case, and a Comet we must behold, if your *Astronomical Prediction* is to be regarded, I think I may as well take Courage, and resolve to attend the important Event undauntedly.

Cleon. Fortitude, my *Euphrosyne*, is an excellent Virtue; and here I must admonish you to speak with more Reverence of astronomical Predictions, or else you may chance, one Day or other, to be accosted in the *Pontifical Style*, and be told, *That Astronomers only have Infallibility on their Side; that their Prophecies are sacred and certain Truths; that they must be believed, or that an implicit Faith in all they say is your highest Duty, and absolutely necessary to your future Reputation; that——*

Euphros. Hold, *Cleonicus*, too much of this kind of Denunciation does not sound well after a *liberal Education*; you are now talking to a Woman, and they are frail Creatures, God knows; if we should be guilty now and then of a little *astronomical Infidelity*, we hope it may be looked upon as a *venal Crime*, and for which we may be entituled to an *Indulgence*.

Cleon. You are quite on the right Side of the Question, Sister; the Ladies are sure to be forgiven, with or without *Confession*.——Now we are on this Subject, what will you think of a Prophecy or Prediction of a Heathen, the celebrated *Seneca*, in the following Words?

“ I cannot assent to our Philosophers, nor think the Comets
“ are Fires suddenly kindled, which appear a-while, and are
“ then extinguished; but I reckon them among the eternal
“ Works of Nature——And why should we wonder that
“ Comets (such a rare Spectacle in the World) should not yet
“ be restricted by certain Laws; nor have the Times of their
“ appear-

108 *The young GENTLEMAN*

“ appearing or disappearing known, as they take their Courses
 “ through such prodigious Intervals of Space.—The Time
 “ will come when a Day shall bring to light, and the Diligence
 “ of a future Age discover, those Things which now lie hid.

“ The Time will come in which Posterity will wonder that
 “ we were ignorant of Things so very plain.—A Per-
 “ son shall one Day arise, who shall demonstrate into what
 “ Regions the Comets wander, why they move so seperately
 “ from the rest of the Planets, and how large, and what kind
 “ of Bodies they are.”——

I say, dear Sister, what can you think of all this, when if you could read Sir *Isaac's Principia*, and there see every Particular of this whole Prediction fulfilled to a Tittle, and no other Man besides Sir *Isaac* did so much as even to attempt the arduous Task.

Euphros. Think, why what could one think less than that he prophesied of that very great Man.—But though I am not able to understand the Writings of that Philosopher, yet, if I remember right, you once told me, that you could make the Manner of the Comet's Motion intelligible by a proper Instrument, as well as those of the Planets.

Cleon. I did so; the Instrument I mean is called the COMETARIUM, and which I shall now spend one Quarter of an Hour in explaining it to you.—Here is the Machine.—

Euphros. And a beautiful one it is; I can almost tell the Use of it by its very Appearance; the Brass-ball C, is the Comet, I dare say; and the long oval Groove, the Orbit in which it is to move about the Sun, which I observe is engraved at one End of it.

Cleon. Very right, my *Euphrosyne*, this Instrument shews the Motion of the Comet of the Year 1682, whose Period is $75\frac{1}{2}$ Years.

Euphros. Then that Period, or those Years, I suppose, are represented by the Circle FG, and the Hand H, pointing out the particular Year of the Period, for any Position of the Comet in its Orbit: am I right *Cleonicus*?

Cleon. So very good is your Apprehension, that it almost makes a Description of the Instrument unnecessary.

Euphros.

Euphras. Not so, indeed; for I can scarce tell what Use that long Wire is of that goes through the Body of the Comet, or of the little Ball E at the End of it; or the Meaning of the large Circle of Stars, though I partly guess at them too.—

Cleon. These Things will all be easy to *Euphrosyne* when the Machine is in Motion.—Observe, when I turn the Winch, the brazen Comet moves, and with a very unequal Pace in its elliptic Orbit, about the *focal Sun* at S.—That when it is nearest the Sun (in what is called the *Perihelion* at B) it moves very quick,—and, on the contrary, at its greatest Distance (or *Aphelion* at A) it moves extremely slow;—and consequently, that in its Return to the Sun, its Motion is always *accelerated*, and constantly *retarded*, as it recedes from the solar Focus.

Euphros. All this I observe and understand with Pleasure.—But now for the Reason of it, *Cleonicus*, if I must be a Philosopher, let me be a rational one or none at all.—Why moves the Comet with such an unequal and variable Motion?—When it is got so far off, what brings it round again, or why does it not keep on increasing its Distance from the Sun, and with a decreasing Motion arrive at last somewhere at a State of Rest?

Cleon. Why, truly, my *Euphrosyne*, these are very reasonable Queries, but they are more easily asked, than their Solutions are to be understood, till you have made a little further Progress in the Elements of Astronomy. I can only say at present, that one Reason of the Comet's Motion, is the *Power of Gravity*, by which it tends towards the Sun in every Place; and because this Power is greatest when the Distance is least, the Comet will there of Course move quickest; and at greater Distances, where the Force of Gravity is less, the Motion will be retarded and become slower in Proportion. But there are other Causes co-operating to produce this sort of Motion, and when they are explained by Experiments hereafter to be made, you will see the Reason why the Comets must necessarily return, and move in elliptic Orbits.

Euphros. I am content to stay till then, though I fear it will be a pretty while first.—But, *Cleonicus*, is not the Use of that Wire to keep the Comet in the Groove, and to oblige it, at the same Time, to move about the Sun?

Cleon.

Cleon. It is just the Thing you mention;——and farther, you observe the Part of the Wire beyond the Comet, grows gradually longer as the Comet approaches the Sun, and shorter as it returns from the Sun; and that therefore, it does, in some Measure, not unaptly resemble the *Comet's Tail*?

Euphros. Indeed it will serve for that Purpose very well, and naturally enough represents the Rising and Encrease of that wonderous Exhalation, as the Comet approaches to the Sun, and its gradual Diminution as it retreats from the same.——But does not that little Ball at the End of the Wire, answer somewhat like the same Purpose as the Bead in the stellated Planetarium for the apparent Motion of *Venus*?

Cleon. In part it does, but not altogether.——Here you are to suppose an Eye placed in the Sun and viewing the revolving Comet in its Orbit; the apparent Motion of the Comet in this Case, would be shewn by the small Ball among the Stars in the Sky, as that Ball appears, to such an Eye, to move by the Stars on the Circle IK. And the Inequality of the apparent Motion of the Comet among the Stars, is much greater than that of its true or real Motion in its Orbit.

Euphros. Can you make this Matter intelligible to such a Novice as I am, think you, *Cleonicus*?

Cleon. I make no Doubt of it; for first, you observe that the true Velocity of the Comet is slower in its Aphelion at A, than in the Perihelion at B, and it is just so much slower as the Distance is greater, viz. As SA is greater than SB. But, secondly, when the Comet is at B, in its nearest Distance, it is slower than the small Ball upon the starry Circle at L, in Proportion as the Distance of the Comet SB, is less than the Distance of the Ball SL. Therefore, upon the Whole, by the Velocity of the Comet at its greatest Distance at A seen from the Sun, or upon this Instrument, is as much less than the apparent Velocity of the same Comet among the Stars at L, when the Comet is nearest of all to the Sun at B, in Proportion as *the Square of the greatest Distance SA, is to the Square of the least SB.*

Euphros. If I do not nicely understand your Proportion of Squares, and such Things, you must excuse me, at present.——I can plainly enough see the Difference of the Motion in those two Places is prodigiously great, and an extremely pleasing



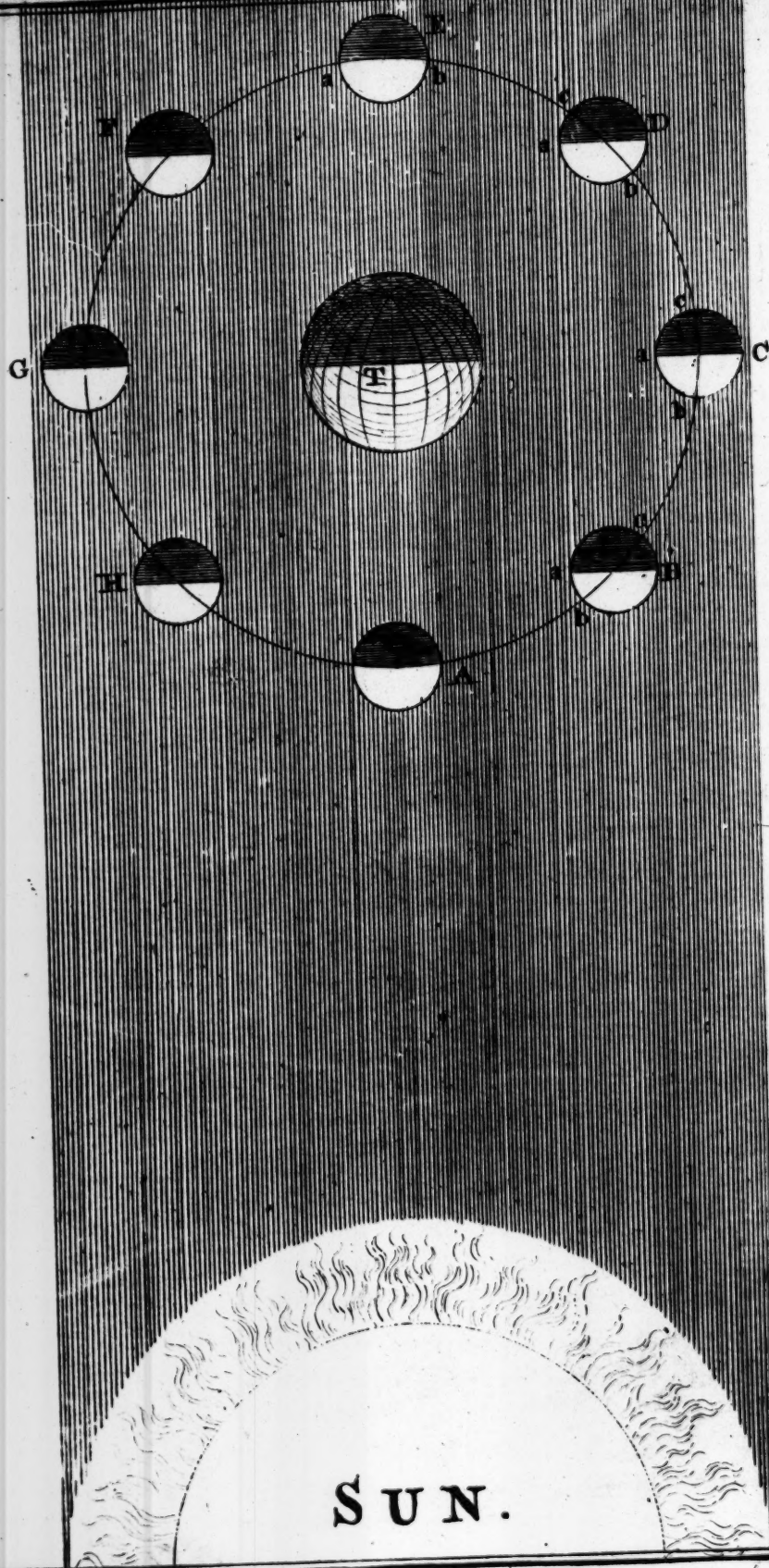


Plate XII.

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pleasing Phænomenon it is——But say, *Cleanicus*, how will the Comet appear to move to an Eye on the Earth, to us for Instance, when the next comes round?

Cleon. The Comet always appears to us to move in a great Circle through the Heavens; to go forwards, and backwards at Times; to rise before, and set after the Sun; and such other Phænomena as we observed of the Planets, which, were it necessary, we might explain in the same Manner as was then done; but of these Things I shall give you a more particular Account when the next Comet appears, and illustrate each Phænomenon by Experiments on the Comet itself.

Euphros. Truly, you almost make me wish for the Comet's Return; the Thing which before filled me with Apprehension and Horror, you have now rendered not only not dreadful, but even desirable.

Cleon. It is always one good Effect that Philosophy has, to deliver the Mind from the Infamy of Ignorance, and those base Sentiments and slavish Fears that continually subject it to unnecessary Pain and Anxiety. In short, it gives the ingenious and liberal Mind a Pleasure in viewing those Phænomena of Wonder-working Nature, which vulgar and superstitious Souls construe into direful Omens and Prodigies of Fate; and scare themselves, and their unthinking Neighbours, with Notions of divine Wrath and Judgment much oftner than there is Occasion for.

Euphros. You speak Truth undoubtedly; yet our Frame will be somewhat shaken at such amazing and unusual Appearances.——I think you said the next Comet will appear in the Winter of the Year 1757; I suppose that is shewn by the Motion of the Hand H, of the Circle GH, divided into $75\frac{1}{2}$ equal Parts, over which it moves, I see, in one Revolution of the Comet.

Cleon. That is the very Case; for you observe when the Comet is nearest the Sun at B, the Index H of the Circle of Years, points to the Beginning of that Circle, or O; after which, as the Comet revolves, the Index points to 10, 20, 30, &c. shewing the respective Places of the Comet for every ten Years of the Period. And since in 1682, this Comet was in its Perihelion at B, it will be at its Aphelion at A, in half the Time of the Period, viz. $37\frac{1}{2}$ Years, which was in the Year

1720;

1720; therefore if to this we add the other Half, it will bring it again to its Perihelion B, which will be 1757 $\frac{3}{4}$, or rather in the Spring of the Year 1758; but for the particular Time to a Week or a Month, we cannot answer; it is sufficient that at present we can predict a Comet will nearly about that Time return.

Euphros. Well, *Cleonicus*, I cannot say but your *Cometarium* gives me an agreeable Foretaste of the exquisite Pleasure that such a Phænomenon will afford me when it happens in Reality. — But my Curiosity is not yet quite satisfied; methinks I should be glad to see the Inside of this Instrument,——could you oblige me in this Respect without too much Trouble?

Cleon. Nothing is more easy—I only take off the Wire and Index; it is then but a common Box—I unlock and lift up the Lid, and you see the Simplicity of the Mechanism at once.

Euphros. There is but a small Matter of it, indeed,—only two circular and two oval *Wheels*, as I may call them; I should have thought there must have been more Work necessary to have produced such an inequable, yet regular and extraordinary Motion, as that of a Comet.

Cleon. * On the long Piece of Wood AB, are placed two circular Wheels, EF and IH, the first of these is turned by the Worm or endless Screw G, by the Handle K: The Axle CD of this Wheel goes through the Lid, and carries the Hand H over the Circle of the Comet's Period. (See Plate X.) The second Wheel IH above, and the elliptic Wheel LM, below the Bar AB, are both fixed on the same Axle, and therefore must both move together. The other elliptic Wheel NO, is connected with the former by a Cat-gut Line in a Groove made in the Perimeter of each oval Wheel. And the Axle P, fixed in the Focus of this Wheel, does also go up through the Lid or Cover, and carries the Wire and Comet upon it, as you saw on the Top of the Instrument. Now it is to be observed, that the Edge of the second Wheel NO, is constantly applied to that of the first Oval LM, and is moved by it always at unequal Distances from the Center, or rather Focus Q, and therefore the Motion must needs be very unequable, while that of the circular
Wheels

* See Plate XI.

Wheels is constantly the same. Whence by this Contrivance, an *equal Motion*, you see, *produces a very unequal one*; which is a Sort of mechanic Paradox.

Euphros. Truly it is, *Gleonicus*, and I could never have thought which Way it was to be done; and I cannot but admire the singular Structure, and curious Mechanism of the Parts — To see an uniform Motion in the circular Wheels — A different Motion in every different Part of the first oval Wheel, and yet in the same Part the Motion is uniformly and always the same — And lastly, to see so very unequal a Motion in every Part of the second Oval; I say, to observe so many variable and dissimilar Effects in so small and simple an Instrument; and at the same Time explanatory of the most unusual and extraordinary Phænomena of the System, is what instructs and entertains me beyond any Thing I could have imagined. — But I fear I have kept you too long upon a Subject, which, however new and engaging to me, may in some Degree prove tedious to you, who understand it so well.



The Young GENTLEMAN and LADY'S
P H I L O S O P H Y.

PART II.

DIALOGUE I.

Of the MOON.

Euphrosyne.



OUR last Conversation, *Cleonicus*, concluded our Speculations of the larger Coelestial Bodies of the System, viz. the *Primary Planets* and *Comets*; the Order of our Method, I presume, brings us now to those of the *Secondary Glafs*.

Cleonicus. Yes, as we have considered the Sun the Center of the Great System, about which the *Chorus* of the largest Planets move; so now we shall proceed to consider the Bodies of some of those Planets as the Center of a lesser System of *Secondaries*: And of these we have but three, viz. the *Earth*, *Jupiter*, and *Saturn*.

Euphros. To the *Earth* you assign one Moon; to *Jupiter*, four; and to *Saturn*, five, if I remember right.

Cleon. 'Tis very right: Of these we will discourse in Order, beginning with the *Moon* pertaining to the *Earth*; which as it is the nearest of all the heavenly Bodies to us, so it appears the most perfect, either by the Eye or Glafs; and exceeds even the Sun itself in its apparent Magnitude. No Wonder, therefore, *Moses* should call it a *great Light*.

Euphros. I remember *Milton's* Description of the Creation of the Moon, which is very beautiful. Having described that of the Sun, he says,

—Lefs

Less bright the Moon,
But opposite in levell'd West was set,
His Mirror with full borrowing her Light
From him, for other Light she needed none
In that Aspect, and still that Distance keeps
Till Night: Then in the East her Turn she shines
Revolv'd on Heaven's great Axle; and her Reign
With thousand lesser Lights dividual holds.
With thousand thousand Stars that then appear'd
Spangling the Hemisphere.——

Cleon. To your Description from Milton, I shall add that of Mr. Cowley, which has a peculiar Beauty and Sweetness.

He smooth'd the rough-cast Moon's imperfect Mold,
And comb'd her beamy Locks with sacred Gold;
Be thou, said he, Queen of the mournful Night,
And as he spoke, she rose o'er-clad with Light;
With thousand Stars attending on her Train,
With her they rise, with her they set again.

Euphros. This is a sweet Description indeed; but let us have a little Philosophy with the Poetry. I have a great many Questions to ask about the Moon; and pray, in the first Place, what Distance may she be from the Earth?

Cleon. The true Distance of the Moon from the Earth is always variable; being sometimes greater, sometimes less; but when nearest, she is distant from us about two hundred and twenty thousand Miles.

Euphros. Well, the next Question of Course is of her Magnitude.

Cleon. The Moon is in Diameter two thousand one hundred and seventy-five Miles. Wherefore the Moon is about 50 Times less than the Earth.

Euphros. But as I remember, she is near as big as the Planet Mercury.

Cleon. Yes, she is so; but Mercury being above one hundred and forty Times farther from us, is the Reason why he appears
so

so small, and she so large, in Comparison of each other.

Euphros. What is the precise-Time of her Revolution about the Earth?

Cleon. She moves from *West* to *East*, in about 27 Days, seven Hours, and 43 Minutes.

Euphros. I think there is no other apparent Motion of the Moon but that each Day from East to West, which, I presume, you impute to the daily Motion of the Earth about its Axis.

Cleon. You are right in what you say last; but even the Moon's periodical Motion about the Earth, is apparent enough, if well observed: For, suppose the Moon were this Night just by any fixed Star, if you observe her To-morrow Night at the same Time, you will see her at a considerable Distance from that Star towards the East; and the second Night twice as far Eastward; and so on, till she has performed a Revolution, and comes in Conjunction with the Star again; advancing each Day a very sensible Distance Eastward.

Euphros. This is an Observation I shall be very well pleased with, and will prove it the first Opportunity. But, pray, *Cleonicus*, has the Moon any other Motion but that about the Earth now mentioned?

Cleon. Yes, she moves about her own Axis too.

Euphros. In what Time?

Cleon. Just in the same Time as she moves round the Earth.

Euphros. Indeed! Why the Moon has something very surprising and peculiar in her Motion.

Cleon. She has so; *her Days and Months are of an equal Length*; which can be said of no other Body in the Heavens that we know of.

Euphros. But how do you prove this, by any Method that I can understand?

Cleon. Yes, very easily; for considering the Moon as a Globe revolving round the Earth as a Center, having its Superficies all over variegated with light and dark Parts, it will from thence be easy to conceive, that if different Parts of the Superficies be at any Time turned towards the Earth, it will by that Means be very discernable to a Spectator at the Earth.

Euphros.

Euphros. Undoubted it would, from the different Appearance of those Parts or Spot.

Cleon. But you know this would necessarily be the Case, were the Moon to be view'd in different Parts of her Orb, supposing she had no other Motion.

Euphros. I conceive it would, for all the Part, or Hemisphere, turned towards us in one Part would be quite hid from us in the opposite Part; and all the Parts visible in the first Case must be now invisible.

Cleon. Very good, my *Euphrosyne*: But since you observe that in what soever Part of the Orbit the Moon is in, the same Face, or the same Appearance of Spots is always observed, without any sensible Variation, she must of Necessity have such a Motion about her own Axis as turns every Moment so much of her Superficies from our View, as is turned to us by her periodical Motion; that is, she must move in the same Time about her Axis as she does about the Earth.

Euphros. Your Reasoning is certainly very just, and amounts to a Demonstration. But why must it be so? Why, *Cleonicus*, was it not permitted us to see the other Half of the Moon's Surface?

Cleon. The Almighty only knows! Any other diurnal Motion but what it has would have gratified our Curiosity with that pleasing Prospect, from which we are now eternally excluded. But as it may not only be satisfactory, but also instructive to see this Matter represented in the *Planetarium*, from the same Cause as produced in the Heavens, viz. the Power of Attraction — Therefore, you observe, on the central Part I place the Earth, and at a Distance, on a proper Stem I suspend an Ivory Ball by a String, so that it is free to move any Way.—But now the Machine is in Motion. You observe the Ball which represents the Moon keep moving about the central Earth, but ever with the same Part towards it, while the Earth itself is constantly turning all Parts of its Surface towards the Moon.

Euphros. I can't but observe it with equal Curiosity and Wonder. But you know my inquisitive Temper, and you must shew me the Reason of the Thing before I shall be satisfied.

Cleon.

Cleon. I am never better pleased than to find such a Disposition in Pupils.—You are soon convinced of the Reason of this Phenomenon—I take the Earth off from a small Stem of Steel, which is an *artificial Magnet*, and there is a Piece of a natural Magnet within the Ball or Moon, and the Power of Magnetism here causes the Moon always to shew or turn the same Part towards the central magnetic Earth just as it is effected by the *Power of Gravity* in the Heavens.—Hence not only one Half of the Moon is constantly hid from us, but our Earth is also at the same Time unseen by those who inhabit that invisible *Lunar Hemisphere*, for you will easily understand that those we cannot see can never see us.

Euphros. That is a very plain Case—and one Thing more I observe, *Cleonicus*, and that is, the Side of the Moon next to the Earth is never dark; for it is always illumined by the Sun's direct Beams on one Part, or by those Rays reflected from the Earth on the other.

Cleon. What you say is very true; the Earth is (as I may truly say) a noble Moon to those Lunarians who are blessed with a Sight of it.—Our full orb'd Earth is a Moon more than sixteen Times as large to them as their puny Moon is to us.—They also see the pleasing Appearance of Land and Water, fiery Meteors, Clouds, nay our Towns and Cities are seen by them, (if they did but know it) in each Revolution on the Earth.

Euphros. Well, I almost envy them the Pleasure.—But let us make the most of that Part of the Moon we are permitted to see, which if you please to shew me thro' a Telescope as you promised, I am perswaded it will afford me an agreeable and delightful Spectacle.

Cleon. That, my *Euphrosyne*, I'll readily do; and through such a Telescope as will just take in at one View her full enlightened Orb, which now you see rising with such Majesty, and advancing up her arched Path with solemn Pace in yonder eastern Sky.

Euphros. I see her; she is just risen, large, bright, and full faced; pray, fix the Tube at this Window, and we may view her without stirring from our Place.

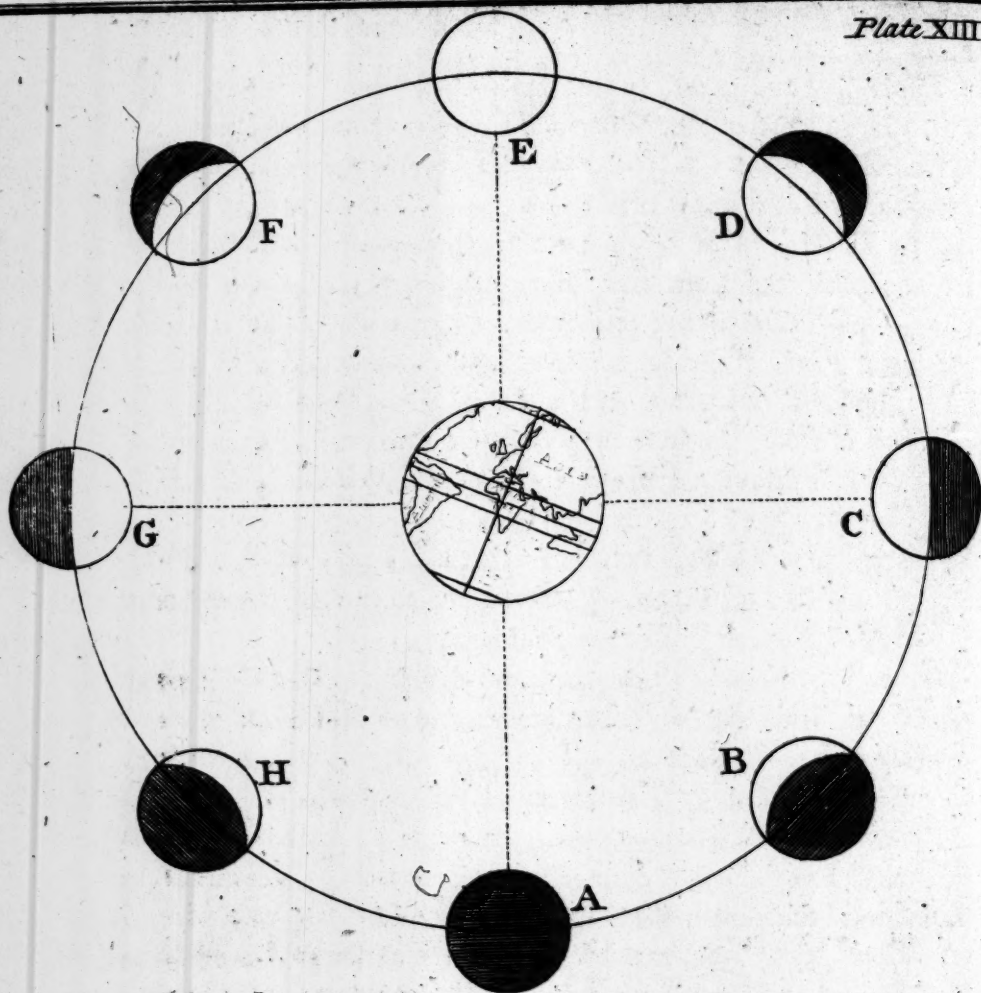
Cleon.

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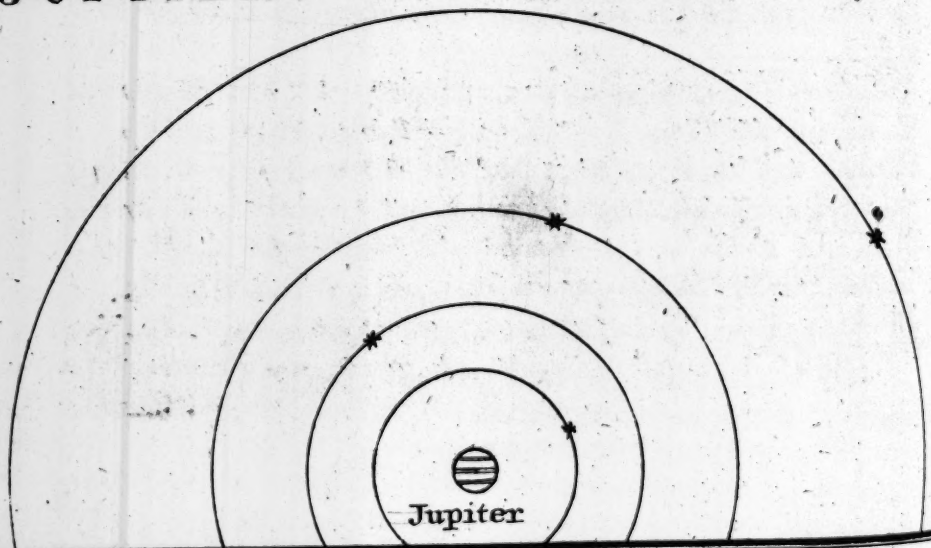


PHASES of the MOON.

Plate XIII.



JUPITER'S four SATELLITES.



Cleon. I will.—'Tis fixed, and ready: View her various Face.

Euphros. I am impatient to peep.—But, Heavens! what do I see! a large Map of some distant World; or rather, an huge terrestrial Globe! for a Globe it seems to be very plainly, and not a flat Surface as it appears to the Eye.—What are those spacious shining Tracts, those large and obscure Regions?—Those very bright Spots that seem like Stars, shining out of the darker Parts,—particularly that remarkable large, round Spot, towards the lower Part of the Orb, which shines with a steady Lustre above the Rest, encircled with a dusky Ring, from which proceed, as it were, Streams or Streaks of Light.—I never before saw so curious a Picture in the heavenly Bodies, or Landscape, or what shall I call it?—I could feast my greedy Eyes 'till Morning with the delightful Prospect!—Say, *Cleonicus*, does it not look like an inhabited World? Tell me the Opinion of the Philosophers on this curious Subject.

Cleon. I will.—They judge the Moon to be a Globe like our Earth, inhabited with various Species of Animals, in various Degrees of Perfection. The bright Parts, they say, must be various Regions of *Land*, shining by the reflected Light of the Sun; the dark Parts, *Oceans, Seas, and Rivers*, which, as they absorb the Light, must needs appear dark. Those bright Spots amid the darker Parts are Islands in the Seas, and Mountain Tops, gilded with solar Beams. The large round Spot you admired, is a prodigious Mountain, elevating its towering Head from a deep and darksome Vale surrounding it; the bright Streaks are Ridges, and Chains of Mountains, which extend themselves therefrom towards different Parts, and to vast Distances.

Euphros. Surprising all! Land and Sea, Mountains and Vales, in the Moon! Wonderous Similitude to our Earth! What would the Poets have said? How beautifully would they have described this pleasing Theme, who were so lavish in the Praises of *Parnassus* and *Helicon*, and *Tempe's* pleasant Vale?

Cleon. They would have been proud of such a Subject no Doubt. The Phases, and Spots of the Moon, have been thought a Theme not unworthy the Muses, as appears in the

Strains of some of our modern Poets. Of whom, thus Mr. Brown.

*Regard the Spots which mark the lunar Face,
Her Figure changing in her monthly Race.
A Crescent now, but feebler Light she yields;
Now half her Disk her bounteous Brother gilds.
Now rising in the East, full-orb'd she glows,
And o'er the Night her silver Mantle throws.
The Roughness on her broken Edge reveals;
Her Surface mask'd with Vales, and pointed Hills.
Her brighter Parts, the Sage mountaineous deems;
Her darker, Oceans, Seas, and ample Streams.*

Euphros. Well, I give you my Word, *Cleonicus*, if you say much more, I shall scarce forbear wishing myself there, to view the vast Countries; to see what Sort of People inhabit them; to observe their various Animals, their Trees, and Plants, their Arts and Sciences, their Seasons and Weather; for all those Things, I presume, you allow are there as well as here.

Cleon. Most Philosophers do allow it, but some deny the dark Parts to be Seas, and say they are either Vales and deep Caverns, or else Land, of such a Mould as will not reflect Light enough to make it look bright like the Rest. They also deny there is any Atmosphere, or Body of Air about the Moon, and therefore no Vapours or Rain, &c.

Euphros. Indeed, *Cleonicus*: Pray, if there be no Air, how do the Inhabitants and Animals live? and if no Rain, how do Trees and Plants grow?

Cleon. I can't tell what Answer they would make to such Queries. Sure I am, that Animals and Vegetables like ours, cannot live or grow where there is no Air nor Rain; and therefore they must be either different from ours, or none at all; which Supposition will make the glorious Orb of the Moon of very little Consequence to us, and none at all to itself; an huge, but uninhabited Wild of barren Hills and gloomy Vales: A Notion of it quite unworthy its Maker.

Euphros. The Philosophers then, I find, are not agreed what Kind of Entertainment the Moon will afford one, and 'till they

they are, I shall wave all Thoughts of going thither. The next Thing I would require of you, is how it comes to pass, the Moon every Month puts on such a Variety of Faces, appearing now *full*, now *halved*, then *horned*, and not at all when *new*? But I recollect myself; you explained these Appearances in the Planet *Venus*, and those of the Moon, I presume, happen after the same Manner.

Cleon. They do; but it will be worth while to be a little more particular in explaining the lunar Phases. You'll easily conceive the Reason of them from this little Scheme; where you see the large Sun darting forth his Beams, which, at the vast Distance of the Earth and Moon, fall nearly parallel on them. T is the Earth, and A, B, C, D, E, F, G, H, the Moon in several Parts of its Orbit circling round it. Here first you observe, that Half of the Earth and Moon, which is towards the Sun, is wholly enlightened by it, and the other Half, which is turned from it, is totally dark.

Euphros. This I apprehend very well, it being evident from the Figure.

Cleon. Consequently the Moon, when it is in the Position A, that is, in *Conjunction*, or exactly between the Earth and Sun, will have all her enlightened Part turned towards the Sun, and all her dark Part towards the Earth; in which Case we cannot see her, and is therefore said to be a *new Moon*.

Euphros. I take you very well; pray go on.

Cleon. When the Moon has gone from A to B, then if that Half, *b a c*, which is turned to the Earth, a small Portion of her Surface is enlightened, as *a b*, and will appear of the Form represented at B, in the other Scheme, (*see Plate XIII.*) which shews you the *Phases* of the Moon.

Euphros. Very good; and now, *Cleonicus*, I suppose you say the Moon is *horned*, from the Figure she makes; do you not?

Cleon. Yes, my *Euphrosyne*, she is then said to be *horned* or *corniculated*, which is all one; but she becomes gradually less and less as she approaches to C, in which Situation she is said to be in her *Quadrature*, or Square to the Sun; and then one Half of that Part towards the Earth is enlightened, and appears as at C among the Phases. She is now said to be *dichotomized*, *bisected*, or a *Half Moon*.

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Euphros. And thus when she comes to D, I see the greatest Part of that Half towards us is enlightened, and appears of the same Face as at D in this other Scheme; and what Name have you for it then, pray?

Cleon. She is then said to be *gibbous*; and this Phase or Aspect increases till she comes to the Situation E, where she is in *Opposition* to the Sun, and consequently turns all her illuminated Surface to the Earth, and shines with a *full Face*, as you now behold her; for which Reason she is called a *Full Moon*.

Euphros. All this I conceive perfectly well from the Schemes; and also I see that as she passes the other Half of her Orbit, from E by F, G, and H to A again, she puts on the same Faces as before, but in a contrary Order and Position.

Cleon. Very good, Sister; I see you have a right Notion of the Matter, and need nothing further to be said on this Head. I doubt not also, but you will easily conceive that when she is *new*, and seen in the same Part of the Heavens with the Sun, she must needs rise and set with the Sun; as on the contrary, when she is at E, a full Moon, being exactly in an opposite Part of the Heavens to the Sun, she must then rise when the Sun sets, and set when he rises.

Euphros. Yes, this I easily understand; but am at a Loss to know the Time of her Rising and Setting in any other Situation.

Cleon. No Wonder if you are, since it is always variable; but this much you may know, that all the while the Moon is passing from A by C to E, she is to the *East* of the Sun, and rises and sets after him; but in going from E, by G, to A, she is *West* of the Sun, and rises and sets before him: *Always shining such a Part of the Night as is proportional to the illuminated Part of her Surface towards us.*

Euphros. Dear Brother, I am pleased when I can get but a general Idea of Things; to know but something is infinitely more satisfactory than absolute Ignorance.—But the Night is far advanced, pray answer me one or two Questions more very briefly: Is not that a reflected Light with which the Moon shines thus pleasantly?

Cleon. It is; and therefore so exceeding weak and languid, in Comparison of the Sun's Light, that the greatest Burning-Glass

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Glass will not collect enough to make a *sensible Warmth*. —
And those who have made the Computation, say, the Full-moon
Light compared with Day Light is *ninety thousand Times* less than
it. Of the full Moon, and her borrowed Light, thus Mr.
Baker.

*When God appoints, the horned Moon renews
Her waining Light, and her whole Visage shews.
Fulfils her Course in Circles yet unknown,
And cheers Mankind with Lustre not her own.*

Universe.

Euphras. Cheers Mankind indeed! — But, pray, has
not the Moon a very great Influence on the Earth and Plants,
and Animals thereon?

Cleon. It would be endless to recount all the senseless Whim-
sies that have possessed the Noddles of the credulous Vulgar, in
this Respect. *Hudibras* is very witty on this Subject, and very
deservedly.

*The Queen of Night, whose vast Command
Rules all the Sea and half the Land,
And over moist and crazy Brains,
In high spring Tides, at Mid-night reigns.*

Tho' we are not to imagine that because some have ascribed too
much Dominion to the Moon, she has none at all; by her Near-
ness to the Earth, she very much affects the Air by the Power of
Gravity, and cause such Alterations therein as have, doubtless,
considerable Effects thereon, with Respect to the Weather at
sundry Times. Also, she must be allowed to have some Influ-
ence on the System of Humours and Juices in the Bodies of
Plants and Animals, since we find the Ebbing and Flowing of
the Sea are certainly the Effects of her Attraction (as we shall
more particularly consider hereafter.)

*Her destin'd Rule, o'er Ocean she presides,
And pours upon the Shore her lagging Tides.*

Universe.

Euphras.

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Euphros. Well, be that as it will, I am not much concerned. — 'Tis sufficiently late, but the Moon, like a *Mid-night Sun*, invites us with her serene and pleasant Lustre, yet to resist the Laws of tyrant Nature, and banishes Sleep from my Eyes; the Bed is a gloomy Idea. — I could, methinks, spend the whole Night in walking over the pleasing shady Scenes of the Park — but Family Order forbids it.

Cleon. Such a Moon-light Night is extremely delightful indeed! The Poets were sensible of this, and have nobly described the Pleasures thereof. Thus antient *Homer*,

*So when the Moon, refulgent Lamp of Night,
O'er Heav'n's clear Azure spreads her sacred Light;
When not a Breath disturbs the Deep serene,
And not a Cloud o'ercasts the solemn Scene;
Around her Throne the vivid Planets roll,
And Stars unnumber'd gild the glowing Pole.
O'er the dark Trees a yellower Verdure shed,
And tip with Silver ev'ry Mountain's Head;
Then shine the Vales, the Rocks in Prospect rise;
A Flood of Glory bursts from all the Skies;
The conscious Swains, rejoicing in the Sight,
Eye the blue Vault, and bless the useful Light.*

DIALOGUE II.

Of the MOONS or SATELLITES of JUPITER and SATURN.

Cleonicus.

WELL, *Euphrosyne*, how are you disposed to spend this Evening? you see 'tis like to be a very fine one.

Euphros. You seem, *Cleonicus*, to represent the Evening as inviting to a Walk; than which nothing will be more agreeable to me, if you are so inclined.

Cleon.

Cleon. You know, Sister, my Inclinations were always to gratify you in every Thing I can.

Euphros. You are very good for that indeed, *Cleonicus*; but which Way will a Walk be most agreeable? Shall we take a Tour round the Park, or (as we have sometimes done) over the green Corn Fields to that yonder pleasant Hill?

Cleon. The Moon will make the Avenues of the Park extremely agreeable; but the Hill will suit with our Design best To-night, which you know was to take a more particular Survey of the Moons which attend *Jupiter* and *Saturn*.

Euphros. Let that determine us then; I believe we shall have equal Pleasure in going that Way: Are you ready to walk?

Cleon. I have only the Telescope to take, and then I am.

Euphros. You are now ready, I see.—But as we go forward, pray, *Cleonicus*, give me some more particular Account of the Moons, which you say attend *Jupiter* and *Saturn*? and also the Reason why some Planets have Moons, and others none?

Cleon. The Planets *Mercury* and *Venus* have no Moons, because they cannot be supposed to want any in such Vicinity to the Sun; and as to *Mars*, there has been none discovered about him, and it is very likely he has none; either because there may be no Inhabitants there, (for he is a small Planet, and of a different Aspect from all the Rest) or else they may be supplied with Light, by Night, some other Way; perhaps by a native Lustre of the Earth, or Soil of that Planet, which may shine in the Absence of the Sun, like some natural Phosphers with us. The Almighty can effect the same Things by more Ways than one, and generally shews his boundless Power and Wisdom by an infinite Variety of Methods.

Euphros. Well, it seems *Jupiter* and *Saturn* have Moons enough to afford us a Subject of Speculation To-night. Pray, by whom, and how long have they been discovered?

Cleon. The Moons or Satellites of *Jupiter* were discovered first of all by one *Galileo*, a famous Italian Philosopher, who (as himself tells us) in the Year 1610, on the 7th of *January*, at Night, saw three small bright Stars very near *Jupiter*, two on the East Side, and one on the West; these he took to be fixed Stars at that Time, but happening the next Night to view them again, he saw them all three on the West Side of *Jupiter*, which

which made him greatly wonder how this could be, for it was an Event quite inconsistent with the then Theory of the Planets and fixed Stars. On the 10th Night he saw but two, and both on the East of *Jupiter*; on the 11th also he saw but two, and both on the same Side; but one of these was twice as large as the other; and thence he was sure they were not the same he saw the Night before. On the 13th Night, viewing them again, he saw four of these small Stars, three on the West Side of *Jupiter*, and one on the East Side; all nearly in a strait Line. These were all he could ever discover, and by constantly observing their Situation and Changes, found they were not fixed Stars, but Moons, or secondary Planets, revolving about *Jupiter*, in the same Manner as the primary Planets revolve about the Sun. To these he first gave the Title of *Medicean Stars*, in Honour of the Family of the *Medici*, who were his Patrons.

Euphros. No Doubt but this new Discovery was very agreeable News to the Astronomers, and gratefully received by them.

Cleon. Surprisingly so; it is not easy to imagine with what Eagerness they all hastened to view the new Wonder. *Jupiter* had now more Addresses than when he was esteemed a Deity; every one being willing to see the new-discovered Equipage and Attendants of this great Lord; 'till at length their Motions became so well observed, as to be found regular and constant, and so became reduced to a Theory, as perfect as that of the Moon, or larger Planets.

Euphros. Why then, I suppose, you can tell their Distances from *Jupiter*, the Times of their Revolutions about him, &c.

Cleon. Yes, very well. For, by the Theory, the nearest Satellite to *Jupiter* is distant from him about *one hundred eighty-eight thousand Miles*, and performs its Revolution in *one Day, 18 Hours, and 27 Minutes*. The second is distant from *Jupiter* about *three hundred and twenty thousand Miles*, and its Period is *three Days, 13 Hours, and 13 Minutes*. The third Satellite is distant about *five hundred and thirty-six thousand Miles*, and its Period is *seven Days, three Hours, and 43 Minutes*. The fourth, or utmost Satellite, is distant about *nine hundred and seventy-two thousand Miles*, and its Period is in *16 Days, 16 Hours, and 32 Minutes*.

Euphros

Euphros. Then I find that two of those Moons are nearer to *Jupiter* than our Moon is to us; and two of them farther distant from him than ours from the Earth.

Cleon. Very true; and at the same Time you observe, that the periodical Time of our Moon is greater than any of his.

Euphros. I do: And now, if you please, I shall be glad to hear the same Account of *Saturn's* Moons.

Cleon. The first who observed the Satellites of *Saturn*, was Monsieur *Hugens*, who in the Year 1655 discovered one, which is the fourth from *Saturn*. But, as I have told you, *Saturn* has five Moons, and all the other four were discovered by Signior *Cassini*, an *Italian*; the third and fifth in the Year 1671, and the two innermost in the Year 1686. He called them the *Lodovicean* Stars, in Honour of *Lewis the Great*, in whose Reign they were discovered.

Euphros. And is the Theory of these Moons as certain as those of *Jupiter*?

Cleon. They are not so easily observed as *Jupiter's*, by Reason of their great Distance from us; but the industrious Astronomers have found their Distance from *Saturn*, and the Time of their Revolutions, as follow:

The first Satellite is distant from *Saturn* about eighty-two thousand Miles, and his Period is one Day, 21 Hours, and 18 Minutes.

The second is distant about one hundred and seventy-five thousand Miles, and its Period is two Days, 17 Hours, and 41 Minutes.

The third is distant about two hundred and fifty-four thousand Miles, and its Period is in four Days, 12 Hours, and 25 Minutes.

The fourth is distant about six hundred and forty-nine thousand Miles, and its Period is 15 Days, 22 Hours, and 41 Minutes.

The fifth is distant about nineteen hundred and sixty-four thousand Miles, and its Period is 79 Days, seven Hours, and 48 Minutes.

Euphros. Why then I find, that some of *Saturn's* Moons are much nearer, and others much farther from him than are those of *Jupiter* from him.

S

Cleon.

Cleon. They are so.† And now, Sister, we are come to the End of our Walk, we will now take a particular View of those Moons with this excellent reflecting Telescope, and you will see that so true is the Theory of these *secondary Planets*, that those of *Jupiter* will appear situated on each Side of him, just as I have represented them in this little Scheme.



Euphros. Indeed! Can you predict and describe their Order and Position for any given Time so exactly, before it comes to pass? But let me prove you —

Cleon. You shall. See *Jupiter* near South-West — I'll direct the Telescope towards him — It is fixed; see his Moons —

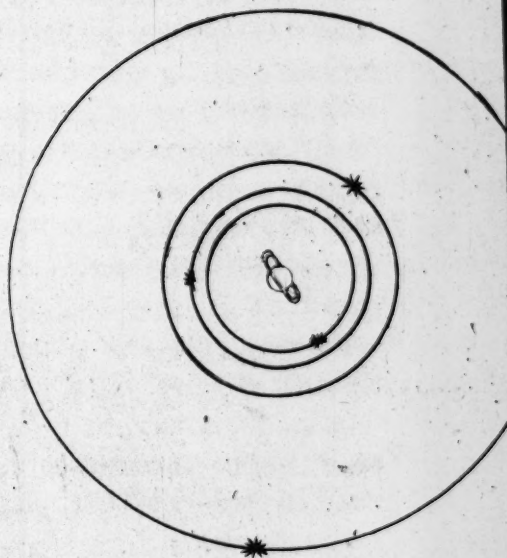
Euphros. I see them plainly as you have represented them — Two on the Left Hand, and two on the Right; one of which latter is near to *Jupiter*, the other at the greatest Distance from him — They appear exceeding plain indeed — and lie very nearly in a strait Line. — *Jupiter* himself shines extremely fair and large — I have lost Sight of one of the Moons — and the others are going after — They seem to have a quick Motion to the Right, and will soon all disappear. — Well, they are a pretty Sight, and worthy the Curiosity of any Person. — But let me now view the Moons of *Saturn*?

Cleon. *Saturn* you see yonder about South-East, in a very good Situation for our Purpose. — I'll turn the Telescope about, and direct it to him. — It is now fixed, *Euphrosyne*; see *Saturn*, his Ring, and two of his Moons all in View.

Euphros. I see them — but the Moons are so very small, I can but just discern them — They are both on the Left Hand of the Planet — *Saturn* shines very serenely — His Ring is a Prodigy never enough to be admired; with this Telescope I can plainly see the dark Sky between him and the Ring — But he hastens from my Sight. — I have feasted my Eyes sufficiently with

† To give the Reader a better Idea of this System of *Saturnian Moons*, I have drawn them all out at such Distances as they have from the Center of their Primary in the Heavens, together with the proportional Magnitude of *Saturn* and his Ring, in Plate XIV.

SATURN'S five SATELLITES





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with the pleasing Wonders, and wish that my Sex in general had the Happiness of tasting these Pleasures along with me. *Cleonicus*, I thank you; take Care of the Glass, and let us now prepare to go home.

Cleon. I am glad you are pleased with the Sight you have had of these Moons; a better Opportunity could not have offered. But the Air seems now cold, and we will return home as you request.

Euphros. And let us walk apace; and as we walk answer me a few Questions concerning these Moons: And in the first Place, why do those of *Jupiter* appear all in a strait Line, in a Situation East and West?

Cleon. This is owing to their moving all in such Orbits round their Primaries as lie right before the Eye, and whose Planes are nearly in the Plane of the Earth's Orbit; for then Circles will be projected into their Diameters by the Eye, and all Bodies in such Circles will seem to move in that right Line.

Euphros. I can scarce tell what you mean. ———

Cleon. I will explain myself by-and-by by Candle-light, and shew you how Bodies moving in such Circles as the Moons do, will appear to move in a strait Line from East to West, while they describe that half Circle which is nearest to you; and then to return back again in the same strait Line, while they pass through the remote Half of their Orbits.

Euphros. If this be the Case, then each Moon appears to go a certain Distance from East to West, and from West to East, in each Revolution in its Orbit.

Cleon. Very true; and from thence also 'tis evident, that the remotest Moon may sometimes seem nearest to *Jupiter*, and the contrary; since the apparent Places of all are constantly changing in a direct Line to and from the Bodies of their Primaries.

Euphros. I observe this Line in which they seem to move passes through the Center of their Primaries, therefore I suppose the Moons do sometimes appear to pass over the Body of their Primaries; do they not, *Cleonicus*?

Cleon. Yes, Sister, they do; and then they appear on the Body of their Primaries, sometimes like bright Spots, and sometimes like dark ones.

Euphros. Pray, how can that be?

Cleon. They naturally appear bright by the reflected Light of the Sun, and their appearing dark is owing to some very large Spot or Spots on the Hemisphere next to us, or from some Quantity of the Surface not apt to reflect the solar Light.

Euphros. The Moons, I apprehend, pass over the Body of *Jupiter*, as they pass from East to West, or describe the nearest Half of their Orbits.

Cleon. You apprehend the Matter right; and you will as easily conceive, that as they move from West to East, or describe the remotest Semi-circle, they will pass behind the Body of their Primary, and so will be eclipsed from our Sight at that Time.

Euphros. I do, *Cleonicus*; and should be glad if I could see any of them thus eclipsed. —

Cleon. I will take an Opportunity one Evening e'er long, to shew you such an Eclipse of these Moons, which you must know is two-fold: For (1.) the Satellite may be hid from our Sight by the Body of the primary Planet, and this is called an *Occultation* thereof. And (2.) the Satellite may be eclipsed by entering into the Shadow of their Primary, and this is called an *Obscuration* of those Moons, or most properly, an *Eclipse* of them.

Euphros. Why then, since the Time of their Revolutions are short, I suppose that one or other of them must frequently disappear.

Cleon. Very frequently; you often see one or more of them missing; and Mr. *Molyneux* tells us he viewed *Jupiter A. D.* 1681, *November 2*, at Ten at Night, and observed a total Disappearance of all his Moons at once: *Jupiter*, says he jocosely, appeared solitary, and as it were deserted by his Guards; and a bold *Lucian* might have pulled him headlong from his Throne without Resistance.

Euphros. Well, that must be a very wonderful Sight, truly. —But our Walk is at an End for To-night, I see; and therefore shall suspend what I have further to query 'till To-morrow, and thank you for the Pleasures of this Evening.

Cleon. Such Pleasures are mutual, I feel them in as large a De-

Degree as you can do, my *Euphrosyne*; which we shall now conclude with the following Lines of Sir Richard Blackmore.

*We've now beheld bright Planetry Jove,
Sublime in Air, thro' his wide Province move;
Four second Planets his Dominion own,
And round him turn, as round the Earth the Moon.
Saturn, revolving in the highest Sphere,
With ling'ring Labour finishes his Year.*

DIALOGUE III.

Of the FIXED STARS.

Euphrosyne.

IF you remember, *Cleonicus*, you was saying this Morning, that our next Conversation in the philosophical Way was to be on the Subject of the *fixed Stars*.

Cleonicus. I did, my *Euphrosyne*; for having already considered all the moveable Bodies of our mundane System, we are of Course led in the next Place to those which are more remote and immoveably fixed through all the visible Part of the Universe.

Euphros. The Stars will afford Matter of most agreeable Speculation; I have many Things to ask concerning them.—See, the Heavens are clear; they begin already to twinkle.—Let us go and take a Walk in the Park to view the spangled Canopy.

Cleon. With a very good Will, my *Euphrosyne*; this fine Season is very auspicious to our Designs. The Evening seems to invite us abroad, in the Language of Mr. Baker,

*Come forth, O Man! yon azure Round survey,
And view those Lamps which yield eternal Day.*

Bring

*Bring forth thy Glasses; clear thy wond'ring Eyes,
Millions beyond the former Millions rise:*

Look farther:—Millions more blaze from remoter Skies.

Universe.

Euphros. Exceeding a *propos*: They appear Millions beyond Millions indeed!

Cleon. But don't mistake, Sister; the Meaning is, they appear so numerous through the Telescope, not to the naked Eye.

Euphros. Truth, I think they appear so to the Eye. Is it possible for the Eye to number them over all the Surface of the Heavens?

Cleon. Yes, Sister; all that are visible to the Eye have been numbered long since over all the starry Vault.

Euphros. Surely you joke with me now, *Cleonicus*.

Cleon. Not at all, *Euphrosyne*; the Stars visible to the naked Eye have been numbered in both the Hemispheres, and how many do you think they are?

Euphros. How many! Why, ten Thousand to be sure, and more.

Cleon. No, no, Sister; nor yet so many Hundreds neither: What do you think of five Hundred at most?

Euphros. Think! why I think any one may see more than five Hundred at one Glance, look which Way you will.—

Cleon. I do not wonder to find you thus mistaken, and surprised at what I tell you. People take it for granted, that because they appear a great many, and scattered all over the Sky, that, therefore, they are innumerable; whereas they are not so, but are easily numbered.

Euphros. But give me Leave, *Cleonicus*, I fear you go a Step too far: Does not *Jehovah* tell *Abraham*, that he will make his Seed as the *Stars of Heaven*, as the Sands on the Sea Shore, and as the *Dust of the Earth*, which can't be numbered?—Yea the Scripture says expressly in one Place, that the *Host*, i. e. the Stars, of Heaven *cannot be numbered*, Jer. xxxiii. 22. What say you to this, *Cleonicus*?

Cleon. Nothing that shall reflect on the Holy Scriptures: Only consider, Sister, what a mad Piece of Work would it be

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to insist on the *literal Sense* of the Scripture in every Place? and our Divines will tell you, that in these and such like Places, the Scripture speaks by Way of *Hyperbole*, which is a Figure of Speech very beautifully implying, a *great Number by one infinitely great*.

Euphros. Well, in these Things I must submit to superior Judgment. But since you say they are numbered, pray who numbered them, and what may their Number be?

Cleon. The antient Philosopher *Hipparchus*, of *Rhodes*, was the first who undertook the arduous Task, about 120 Years before Christ; *daring*, says *Pliny*, to undertake a Thing, which seemed to surpass the Power of the Gods, viz. number the Stars for Posterity, and reduce them all to Rule.—His Catalogue contained one thousand and twenty-two Stars.

Ptolemy, the Egyptian Astronomer, enlarged his Catalogue with only four Stars.

After *Ptolemy*, *Ulugh Beighi*, the Grandson of *Tamerlain* the Great, made a Catalogue of one thousand and seventeen Stars.

Next to him the noble Danish Astronomer, *Tycho Brahe*, determined the Places of seven hundred and seventy-seven Stars, and reduced them all to a Catalogue.

Kepler produced the next Catalogue, of one thousand one hundred and sixty-three Stars.

After this *William*, Prince of *Hesse*, computed the Places of four hundred Stars, by the Help of his Mathematicians.

Sometime afterwards the famous Jesuit, *Ricciolus*, enlarged *Kepler's* Catalogue to the Number of one thousand four hundred and sixty-eight Stars.

'Tis also said one *Bayerus* made a Catalogue of one thousand seven hundred and twenty-five Stars.

After this the famous *Hevelius*, of *Dantzick*, composed a new Catalogue, of one thousand eight hundred and eighty-eight Stars.

The late incomparable Astronomer Royal, Dr. *Edmund Halley*, undertook a Voyage to the Isle of *St. Helena*, to observe the Stars in the southern Hemisphere, and at his Return published a Catalogue of three hundred and seventy-three of them.

And lastly, the most complete Catalogue of the Stars, was that made and published by the late Mr. *Flamsted*, in his Celestial History, which contains about three thousand Stars, which
by

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by far the greatest Part are to be seen only with the Telescope. And thus you see *to count the Stars* is no such new or impracticable Thing.

Euphros. I thank you, *Cleonicus*, for this concise History thereof. What will not the Skill and Industry of Men enable them to attain to!

Cleon. You'll further wonder, perhaps, when I tell you, *that there is not the least Star in the Heavens to be seen, whose Place and Situation is not better known, than the Position of many Cities, through which Travellers do daily pass.*

Euphros. That is-very wonderful, indeed; but, I presume, Mr. *Flamsted's* Catalogue does not contain all the Stars that be in the Universe.

Cleon. All! No, nor but a very small Number, in Comparison of what are unknown and unseen. The Number of the Stars through all the Extent of universal Space is, doubtless, infinitely great; but of this no Man can adequately judge.—

Euphros. Be the Number of the invisible Stars as it will, I am sure those which are visible give the Heavens a most agreeable Aspect To-night, and brings to my Mind two Lines of Sir *Richard Blackmore*.

*With Orbs of Light he inlays all the Spheres,
And studs the sable Night with Silver Stars.*

Cleon. The same Poet has another Strain on this Subject, very grand and sublime.

*He spreads the pure Cerulean Fields on high,
And arch'd the Chambers of the vaulted Sky;
Which he, to suit their Glory with their Height,
Adorn'd with Globes, that reel as drunk with Light;
His Hand directed all the tuneful Spheres,
He turn'd their Orbs, and polish'd all the Stars.*

Euphros. The Stars are, to be sure, as well a glorious Theme as a beautiful Scene — But why, *Cleonicus*, do some Stars appear so large, and others so very small?

Cleon.

Cleon. Because some are very near in Comparison of others; by common Experience we know, that equal Bodies at unequal Distances will appear unequal in Magnitude; those which are nearest appearing largest.

Euphros. Can you tell any Thing certain about the Distance of the Stars?

Cleon. No; the Distance of the nearest fixed Star is immeasurably great. —

Euphros. Can you make no Computation or Guess in any wise probable?

Cleon. Scarcely that: Mr. *Huygens* tell us, that the Dog-Star (which is the largest, and consequently the nearest) appears *twenty-seven thousand, six hundred and sixty Times* less than the Sun, and therefore must be above *two Millions of Millions* of Miles from us.

Euphros. Stupendous Distance! —

Cleon. So great, that a Cannon-ball would spend near *seven hundred thousand Years* in flying thither, with the same Velocity it has at the Cannon's Mouth.

Euphros. Amazing! But, pray, must not those Bodies be very large to be visible at such an immense Distance?

Cleon. Yes, immensely large indeed; and not only so, but they must also shine with their own native Light, or else they could never be visible to us at such a Distance.

Euphros. Indeed! Why what will you make of the Stars at this Rate of considering them? I believe People in general look upon them only as twinkling Points, to make the Night pleasant. —

Cleon. This vulgar Notion of the Stars is very poor and low, and utterly unworthy so grand and glorious a Part of visible Nature. The Poet elegantly reproves and derides the Ignorance and Stupidity of such as think the Stars were appointed to serve such mean Purposes, in the following Lines.

*And can'st thou think, poor Worm! those Orbs of Light,
In Size immense, in Number infinite,
Were made for thee alone, to twinkle to thy Sight?
Presumptuous Mortal! can thy Nerves descry,
How far from thee they roll, from thee how high?*

T

With

*With all thy boasted Knowledge can'st thou see
Their various Beauty, Order, Harmony?
If not — then sure they were not made for thee.*

And a little after;

*Correct thy awkward Pride, be wise, and know,
Those glitt'ring Specks thou scarce discern'st below,
Are Founts of Day, stupendous Orbs of Light,
Thus by their Distance lessen'd to the Sight.*

UNIVERSE.

Euphros. One would take a Star, according to these Descriptions, to be in itself somewhat like our Sun. —

Cleon. You have just hit upon the Matter, my *Euphrosyne*; they are by all the modern thinking Philosophers judged to be so many Suns, having their several Systems of Planets circling about them, though by Reason of their Smallness they cannot be seen.

Euphros. Then, according to this Doctrine, the Universe must be filled with solar Systems, which, if they bear any Analogy to ours, must make a glorious Harmony in the grand Composition of Nature; and is such a noble and august Idea of the World, as I never should have conceived or thought of, nor can enough admire!

Cleon. This new and noble Notion of the Universe has fired the Muses themselves, and set the Poets in Emulation who should sing the lofty Theme in the most exalted Strains. Thus one,

*Now if thou can'st the mighty Thought sustain,
If it not akes thy Soul, and racks thy Brain,
Conceive each STAR thou seest another SUN,
In Bulk and Form, and Substance like thine own.*

And a little below;

*Consult with Reason, Reason will reply,
Each lucid Point which glows in yonder Sky,*

In-

*Informs a System in the boundless Space,
And fills with Glory its appointed Place:
With Beams unborrow'd brightens other Skies,
And Worlds, to thee unknown, with Heat and Life supplies.*

UNIVERSE.

Thus another sings;

*Now to fresh Wonders, let thy Search remove;
Seest thou those Orbs that numerous roll above:
Those Lamps that rightly greet thy visual Pow'rs,
Are each a bright capacious Sun, like ours.
The Telescopic Tube will still descry
Myriads behind, that 'scape the naked Eye.
And farther on, a new Discovery trace,
Thro' the deep Circle of encompass'd Space,
How thick (discernable to aided Sight)
Their Constellations crowd the milky Height,
Whose Sphere elude the Reach of naked Eyes,
And seem with Light to belt whiten'd Skies.
If each bright Star so many Suns are found,
With Planetary Systems circled round,
What vast Infinitude of Worlds may grace,
What Beings people the stupendous Space?
Whatever Race possess th' ethereal Plain,
What Orbs they people, or what Ranks maintain?
Tho' the deep Secret Heav'n conceal below,
One Truth of universal Scope we know.
Our nobler Part, the same ethereal Mind,
Relates our Earth to all their reasoning Kind.
One Deity, one sole creating Cause,
Our active Cares, and joint Devotion draws.*

And again:

*Thus has the Muse, but with a transient View,
Roam'd the wide Circuit of our System through;
But Millions more the Pow'r divine has plac'd,
Millions of Suns with circling Planets grac'd,*

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*Suns large as ours, yet to th' unaided Sight,
Points scarce distinguish'd in the Train of Night.
The Ball which swiftly from the Cannon flies,
Piercing with equal Speed the yielding Skies,
Amazing Thought! seven hundred thousand Years
Must travel e'er it reach these distant Spheres.*

Euphras. These Gentlemen descant very finely, indeed, on the wonderful Subject; but as it is of such vast Importance to the forming a right Idea of Nature, I should be glad to hear you rehearse particularly the Arguments on which this Doctrine of *Solar Stars* is founded.

Cleon. I will briefly recite to you the principal, which are as follow:

First. They all shine by their own native Light, which is the Property of a Sun only.

Secondly. They are of a vast Magnitude, like our Sun; or else they could not be seen at such an immense Distance.

Thirdly. They are placed at an almost infinite Distance from each other, as far at least as our Sun is from them.

Fourthly. Were we removed to the Distance of the nearest Star, our Sun would appear no bigger than a Star, and would appear as such among the rest.

Fifthly. At the Distance of the Stars our System of Planets would be invisible; even *Jupiter* himself, by Reason of their Smallness, and feeble reflected Light.

Sixthly. God made nothing in vain, therefore not the Stars, which constitute almost the whole Universe; but they answer some great and glorious Purpose unknown to us.

Seventhly. The Observation of *new Stars*, which are supposed to be the Suns of some new-created Systems; thus our Sun at the *Mosaic* Creation might appear as a *new Star* to others.

Eighthly. Some Stars have decayed, and become quite extinguished, which probably were the Suns of old Systems, which had stood their appointed Time. A Change which our Sun will probably undergo in Time.

Ninthly. The Scripture speaks of a *Plurality of Worlds*; and it is not probable God would make but *one System*, whose utmost

most Extent is but a Point compared with the Universe.—
From these, and such like Methods of Reasoning, it is at least
very probable that each *fixed Star* is a *Sun*, which is the Cen-
ter of a System of circulating Planets of several Kinds, and
that these Planetary Orbs are-inhabited by Creatures of various
Sorts and Degrees of Perfection. — This is agreeable to what
we observe in our Earth and System; accordingly Mr. Baker,

*Heed well this Orb, where Fate has fix'd thy Lot;
Seest thou one uselefs, or one empty Spot?
Observe the Air, the Waters, and the Earth,
Each Moment give ten thousand Creatures Birth.
Here ev'ry Place, so far from lying waste,
With Life is crouded, and with Beauty grac'd;
Nor can those other Worlds, unknown by thee,
Less stor'd with Creatures, or with Beauty be;
For God is uniform in all his Ways,
And every where his boundless Pow'r displays;
His Goodness fills immensurable Space,
Restrain'd by Time, nor limited to Place:
His Wisdom form'd great Nature's mighty Frame,
And rules by Laws eternally the same.*

UNIVERSE.

Euphros. I think the Reasons you alledge make it sufficiently
probable to induce any one to believe a *Plurality of Worlds*.—
But we have walk'd 'till the Evening is cold, and the Grass
very dewy; and tho' I have many more Things to enquire a-
bout the Stars, I will, if you chuse it, *Cleonicus*, refer them
'till the next fine Evening, when I shall be glad to have a View
of some of them with the Telescope.

Cleon. That you shall, my *Euphrosyne*; for besides that 'tis
late, we are prevented any Thing of that Kind To-night by
the Clouds coming on, and the Weather growing up, which
Circumstance is aptly expressed by Sir Richard Blackmore.

*His marshall'd Clouds which intercept the Light,
Seal up the Stars, the twinkling Eyes of Night.*

DIA-

DIALOGUE IV.

*The Speculation of the STARS continued.**Euphrosyne.*

AFTER a few tempestuous Nights, I see the Heavens begin to refine, and the azure Expanse renews its sparkling Glory. We will, therefore, now re-assume our Speculation of the Stars, if you please, *Cleonicus*, and consider divers other Circumstances, of which I have not yet a good Notion.

Cleon. You engage me with a great deal of Pleasure, *Euphrosyne*; I shall gladly impart to you all that I know concerning the Stars.

Euphros. The next Question then that I would ask is, whence comes it to pass that *each Star twinkles so vehemently in a clear Night?*

Cleon. The *Twinkling*, or *Scintillation* of the Stars arises from the continual Agitation of the Air, or Atmosphere, thro' which we view them; for the Particles of the Air are always in Motion, and will cause a Twinkling in any distant luminous Body, which shines with a very strong Light. I say, *a very strong Light*, and *a distant Object*; because *near Objects*, as *a Candle*, or *a feeble Light*, as of *the Planets*, will produce no such Appearance.

Euphros. Then none of the Planets twinkle in the darkest Night, do they?

Cleon. No; and by that you may distinguish them at any Time from the fixed Stars; nor will the Stars twinkle, if you view them through a very small Hole in a Piece of Paper, or thro' a Telescope.

Euphros. Pray, let me try that.

Cleon. You shall; take this Telescope, and look at yon sparkling Star.——

Euphros. I see which you mean, give me the Glass——I see it plainly——It appears very steady, nor does it sparkle at all——yet it appears with a very strong Light——But this Telescope does not magnify much, I believe, for I can't perceive that the Star is bigger than it appears without it.——

Cleon.

Cleon. That is not the Fault of the Glass, it magnifies very much; but were it to magnify a hundred Times more, or a thousand, the Star would still appear but as a Point; for by Reason of its immense Distance, it eludes the Force of any magnifying Glass. Yea, on the contrary, the Stars are rather diminished in Appearance, by taking off their sparkling Lustre.

Euphras. Well, then, the next Thing I would enquire is, why they are called *Fixed Stars*?

Cleon. Because they do not, like the Planets, change their Places, or alter their Situations in the Heavens, but keep at all Times the same Distances and Position among themselves; that is, the same Star, at the same Time of the Year, always is seen in the same Place, and at the same Distance from others about it.

Euphras. I know you'll resolve the apparent *nocturnal Motion of the Stars*, from East to West, into a Consequence of the *diurnal Motion of the Earth* the contrary Way; but how happens it that at one Time of the Year we see one Set of Stars in the Sky, and at another Time of the Year another?

Cleon. This arises from the annual Motion of the Earth, and which I will explain to you by this little Scheme; where S is the Sun, and A B C D the Earth, in four Positions of its Orbit; also E F G H the Firmament of the Stars, at an infinite Distance.

Now the Earth in each Situation appears half enlightened, and half dark, representing Day and Night.—And when it is at A, the Sun will appear at Noon in the Heavens at G, and will obscure all the Stars in the Hemisphere, F G H; whereas at Midnight the Point of the Heavens E, will be in the Meridian, and then all the Stars in the other Hemisphere, F E H, will be visible. Do you apprehend me?

Euphras. Yes, pretty well; pray proceed.

Cleon. Then when the Earth, three Months after, is come to the Situation B, the Sun at Noon will be seen at H, and all the Heavens, G H E, will be Day; and over all the other Half, E F G, the Stars will glitter at Night.

Euphras. Then I perceive the Stars in the Quarter F G, will now be visible, which (in the former Position) were not; and those in the Quarter H E, will become obscured by Day-light.

Cleon.

Cleon. You conceive the Thing admirably well, my *Euphrosyne*: In like Manner when the Earth is at C, the Heavens, H E F, will be Day, and F G H Night, where all the Stars will shine.

Euphros. Then that Part of the Heavens which was Day when the Earth was at A is now Night, and so the Stars which were all then invifible are now vifible, and the contrary.

Cleon. Very right, Sister, that is the Cafe; and laftly, when the Earth is at H, the Stars in the Hemisphere, E F G, will be obfcured by Day-light, and thofe in G H E will all be vifible in the Night.

Euphros. Well, I am fully fatisfied in this Point, *Cleonicus*; but why do I fee fome Stars constantly all the Year round, and others but at different Times and Seasons?

Cleon. You might have added too—and *some Stars not at all*. But as this depends on fome Underftanding of the *Doctrin*e of the *Sphere*, you will apprehend it much better when I fhall one Day or other explain to you the *Ufe of the Celestial Globe*.

Euphros. I am willing to wait all proper Opportunities, and am obliged to you for choofing them. And now I fuppofe there remains nothing befides relating to the Motion of the Stars to be confidered; therefore ———

Cleon. Hold, Sister, before we leave this Subject, I fhall juft obferve to you, that there is only one Star in all the vifible Heavens which feems to have no Motion at all.

Euphros. Indeed! Pray, which is that?

Cleon. It is that commonly called the *North Pole*, or more properly the *Polar Star*.

Euphros. Be fo good as to fhew it to me.

Cleon. It is that fmall, but bright Star, which you fee yonder, full North, amidft many other, but fmall Stars; it is ever pointed to by thofe two large bright Stars in *Charles's Wain*, which you obferve a little to the Left Hand.

Euphros. I fee the Star you mean, very plainly; and do you fay it has no Motion?

Cleon. It does not appear to move either with the *diurnal* or *annual Motion*, as all the other vifible Stars do; but view it at what Time of the Night or Year you will, you fee it always in the fame Place.

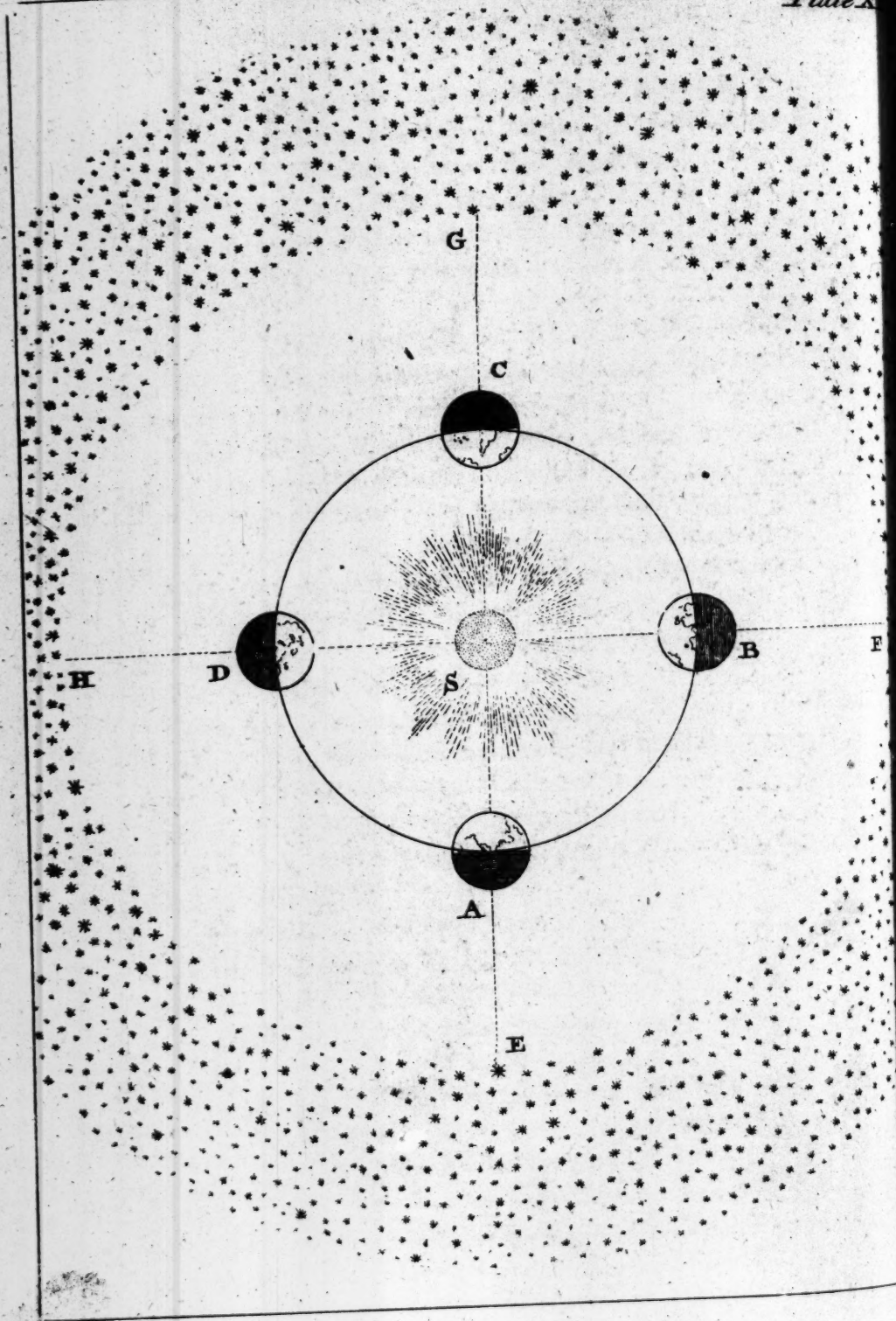
Euphros.

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The Apparent Annual motion of the S T A R S.

Plate X



Euphros. But you seem to intimate by your Way of speaking, that it has some Sort of Motion or other; has it not?

Cleon. It has; but such an one as is not sensible in a long Course of Years, and arises from a Cause that you must stay a while before you can well understand it.

Euphros. To what End then do you mention it to me, *Cleonicus*?

Cleon. Because there is something very surprising in the Consequence thereof: For this Star, though it be now very nearly in the North Point of the World, has such a Motion round a certain Point in the Heavens, as will in Time make it to circulate through the several Parts of the Heavens like other Stars.

Euphros. Say you so; will the *North Star* in Time be seen *Southward* of us? Pray, in how long a Time?

Cleon. In the Space of *twelve Thousand nine Hundred and sixty Years*; for in double that Time, *viz.* in twenty-five Thousand nine Hundred and twenty Years, it makes one Revolution, which is called the *Great, or Platonic Year*, from *Plato* the Philosopher, who, with other of the Antients, supposed that after this Period all worldly Changes would return in the same Manner and Order as before.

Euphros. Is this a *real*, or only an *apparent Motion* of the Stars?

Cleon. Apparent only, as are both the other. And thus much of the *Motion of the Stars*, of which *Dryden* has these Lines,

*As when the Stars in their ethereal Race,
At Length have roll'd around the Liquid Space,
At certain Periods they resume their Place.
From the same Point of Heav'n their Course advance,
And move in Measures of their former Dance,*

Euphros. I observe a manifest *Difference in the Colour* of the Stars, some look *red*, others *pale*; pray, what can be the Meaning of that?

Cleon. You ask a Question I can't resolve.—There is somewhat undoubtedly very different in the Nature both of the Matter and Light of those Stars or Suns; but what that is, their Maker only knows.

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Euphros. I have had my Eye some Time upon a Kind of *brighth misty Spot*, which at first Glance seems like a Star; pray, is it a Star, or what is it?

Cleon. I see what you mean; it is indeed called a *nebulous*, or *misty Star*; but it is not a Star properly speaking: You'll have a better Notion of it when you view it with the Telescope.

Euphros. Give me the Tube, and I'll view it — Bless me, what do I see! — The Glafs is covered with Stars as thick as Bees in a Swarm. — Very small Stars, yet very distinct. — I do see now what it is, indeed — A compound Star, consisting of Multitudes of single ones. — Well, this is a wonderful Sight, on my Word, *Cleonicus*.

Cleon. There is nothing more curious among the Stars, in my Opinion. There are reckoned about six or seven of these *nebulous Stars* in the Heavens; in some of which there appears a bright, lucid Part, in which some Stars appear, as from a white Cloud, and these are reckoned to be Regions of a peculiar Nature, which enjoy a native Light, and an uninterrupted everlasting Day.

Euphros. How infinitely various, amazing, and unaccountable are the Works of Nature! But casting my Eyes on the seven Stars, puts me in Mind to ask a Question I have long intended; and that is, Why are they called the *seven Stars*, when no Person, I believe, can tell above six?

Cleon. In Answer to this, I shall at present only say, that in former Times, 'tis probable, there were *seven* to be seen, one of which afterwards became extinct, and was never more seen; and that as long since as *Ovid's Days*, (who lived in the Time of our Saviour) as is evident by these Verses in his *Fasti*.

*Now rise the Pleiades, those Nymphs so fair,
Once seven number'd, now but six there are.*

Now though there appear but six Stars in this Constellation to the naked Eye, yet take the Telescope and view them, and you will discover many more.

Euphros. Pray, give it me then; I'll view them. — O surprising! — What a Number do I see! I can tell near twenty. — They fill a greater Space than the Glafs will take in. — Some
are

are very large, others small.—There are so many, I can't number them all.

Cleon. I believe so, *Euphrosyne*; for *Dr. Hook* tells us, that with a twelve Foot Tube he counted no less than 78 Stars; and making Use of longer Telescopes he discovered still many more. But that the Universe abounds with numberless Numbers of Stars, you will soon be convinced, by directing the Telescope to any Part of that whitish Tract of the Heavens we call the *Galaxy*, or *Milky Way*.

Euphros. That I'll instantly do.—I see them, innumerable!—They fill the Glass, like the nebulous Star.—If I turn the Tube this Way or that, still nothing but Stars are seen—Most of them very small, some scarce discernable.—The Region of Heaven looks light through all this Part.—Sure we have here a larger Prospect into the Universe.

Cleon. This Part of the Heavens being illuminated by the Lustre of such an Infinity of Stars, gave Occasion to the Heathen Poets to make it the *high Road to Heaven*, or to the *Court of Jove*. Thus *Ovid*;

*A Way there is in Heav'n's extended Plain,
Which when the Skies are clear is seen below,
And Mortals by the Name of Milky know:
The Ground-work is of Stars, thro' which the Road
Lies open to the Thunderer's Abode.*

And our famous *Milton*;

*A broad and ample Road, whose Dust is Gold,
And Pavement Stars, as Stars to us appear,
Seen in the Galaxy, that Milky Way,
Like to a circling Zone, powder'd with Stars.*

Again; the astronomical Poet *Manilius*, speaking of the *Galaxy*, has these Lines;

*Nor need we with a prying Eye survey
The distant Skies, to find the Milky Way,*

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*It must be seen by all, for every Night
 It forcibly intrudes upon our Sight,
 And will be mark'd, for shining Streaks adorn
 The Skies as opening to let forth the Morn.
 And as a beaten Path that spreads between
 A trodden Meadow, and divides the Green:
 Or as when Seas are plow'd, behind the Ship
 Foam curls on the green Surface of the Deep;
 In Heav'n's dark Surface such this Circle lies,
 And parts with various Light the azure Skies.
 Or as when Iris draws her radiant Bow,
 Such seems this Circle to the World below.
 It all surpriseth, our inquiring Sight
 It upward draws, when through the Shades of Night
 It spreads its Rays, and darts amazing Light.*

LIB. I.

Euphros. But why, *Cleonicus*, is this Part of the Heavens stored with such Myriads of Stars more than any other Part?

Cleon. I cannot tell the Reason, but so it is; and hence it is that in this Part, oftener than in any other, we find the *Extinction of old Stars*, and the *Appearance of new ones*.

Euphros. I should be glad to have a short Account of these old and new Stars that you speak of, having never heard any Thing on that Subject.

Cleon. *Hipparchus*, who lived some Years before Christ, is said to be the first who saw or observed a new Star. After many Ages, in the Year 1572, a new Star appeared to *Corn. Gemma*, and *Tycho Brahe*, and became extinct in the Year 1574. It broke out with the Lustre of *Venus*, and decayed very gradually all the Time. Such another was seen in 1604, and died away gradually in about the same Time. In the Year 1696, one *Fabricius* discovered the *Stella Mira*, or wonderful Star, in the *Neck of the Whale*, which is found to appear and disappear periodically, its Period being seven Revolutions in six Years. In the Year 1600, *Wm. Jansnius* discovered another in the *Neck of the Swan*, which has since appeared of different Magnitudes, and is now very small. Another was discovered in the Year 1670, by *Hovellius*, and disappeared in 1672. And in the
 Year

Year 1686, the last new Star was discovered by Mr. G. Kirch, which returns periodically in the Space of about $404\frac{1}{2}$ Days; and these are all the fixed Stars which have altered their Appearance for 160 Years past.

Euphros. Dear *Cleonicus*, I am obliged to you; but fear I tire you with my Impertinencies: 'Tis late, and I'll have done, if you'll only tell me what I am to understand by the Star which I saw this Moment shoot along a good Part of the Heavens.

Cleon. It was not a Star that you saw, my *Euphrosyne*, but only a fiery Meteor kindled in the Air, and then looked like a Star; and as all such Bodies move swiftly, like a *Sky-Rocket*, while they spend themselves, so this *Meteor* seemed like a shooting or falling Star, till it became extinguished; according to the Poet.

*Thus oft before tempestuous Winds arise,
The seeming Stars fall headlong from the Skies,
And shooting thro' the Darkness, gild the Night
With sweeping Glories, and long Trails of Light.*

DRYDEN'S VIRGIL.

Thus also *Manilius*;

*But still, when wand'ring Stars adorn the Night,
The falling Meteors draw long Trains of Light;
Like Arrows shot from the celestial Bow,
They cut the Air, and strike our Eyes below.*

LIB. I.

DIALOGUE V. Of an ECLIPSE of the SUN.

Euphrosyne.

I Have been very anxious about the Weather To-day, how it might chance to fall out, on Account of the Eclipse of the Sun that is to be this Afternoon; but it is at present fine, and
I hope

I hope the Clouds will forbear, and permit us the extraordinary Sight, especially now you are here.

Cleon. I believe it will be a fine Day throughout: It will begin just at $39\frac{1}{2}$ Minutes after Three o'Clock, against which Time I will get the Telescope and darkened Chamber in Readiness for the Observation.

Euphros. What I have often wondered at, *Cleonicus*, is, how any Body can tell when an Eclipse will happen so long beforehand, and to such Exactness of Time.

Cleon. It does seem wonderful to those who know not the Principles they go upon; but I do assure you, my *Euphrosyne*, the Astronomer can foreknow and predict the Time of an Eclipse to a Minute, with the same Ease, and in the same Time as you can raise a Mince-Pye.

Euphros. Indeed! Well, that old Saying is good, *All Things are easy when understood.* But, pray, what is the Meaning of the Word *Eclipse*?

Cleon. The very Nature of the Thing is implied in the Word, which is of *Greek* Original, and signifies a *Defect* or *Deficiency*; and therefore is properly applied to express the *Loss of Light* in the *Sun* or *Moon*. The Word *Eclipse* also signified to *faint*, *swoon*, or *be sick*; and was generally applied to People when in a *fainting Fit*, or *dying away*; and the ancient ignorant Heathens, thinking this to be the Case with the *Sun* and *Moon* at such Times, used to say they were *eclipsed*. Thus *Lucretius*;

*Eclipses may be solv'd a thousand Ways,
For if the Moon can stop descending Rays
By thrusting her dark Self between, and so
Bring sudden Shade, and Night on all below;
Then give me Reasons why there cannot be
Another Thing, too dark for us to see,
And fit to stop the Rays, as well as she?
Or, why the circling Sun, in passing by
Some venomous Places of the neighbouring Sky,
May not grow sick, and pale, and almost die?
Those past, grow well, regain his former Light?
Thus sometime make us Day, and sometime Night.*

BOOK V.

Thus

Thus *Virgil* also in his Petition to the Muses;

*Give me the Ways of wand'ring Stars to know,
The Depths of Heav'n above, and Earth below;
Teach me the various Labours of the Moon,
And whence proceed th' Eclipses of the Sun.*

GEORG. II.

Euphros. I could heartily join with *Virgil* in his Prayer, but I am afraid my Stars never designed me for an Astronomer good enough to understand the Nature of Eclipses.

Cleon. Don't think ill of your Stars till you know you have Reason; I believe there are few Ladies who have not Intellects sufficient to understand the general Doctrine of Eclipses, especially as to the Manner of them, without the mathematical Principles, on which the Theory depends.

Euphros. I shall be glad if I can be an Instance of this to the rest; I presume you must go to Scheming again, if you intend I should understand any Thing of the Matter.

Cleon. Without Figures, or Schemes, none can understand it; but with those Helps they easily may. See here a little Draught of an *Eclipse of the Sun and Moon*.

Euphros. I do; and can assure you that it appears at first Sight so easy and expressive, that I am in Hopes I shall give you but little Trouble in the Explication. I see the Earth in its Orbit about the Sun, and the Moon in two Positions in her Orbit about the Earth; in the first, she is between the Earth and Sun, and casts her Shadow upon the Earth; in the latter, she is involved in the Shadow of the Earth, which is then interposed between her and the Sun.

Cleon. You conceive a very good Notion of the Thing in general, and a few Particulars explained will give you a good Idea of both Kinds of Eclipses. And first, for an *Eclipse of the Sun*, you see that is occasioned by the *New Moon* coming between the Earth and Sun, by which Means her Shadow often falls upon the Earth in some Part, as at C; for to an Inhabitant at C, the Moon will appear to cover the whole Face of the Sun very nearly, and so cause what we call a *total Eclipse of the Sun*.

This

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This is evident by drawing the Lines CMD and COE, from an Eye at C, touching the two extreme Parts of the Moon, M and Q; for those Lines continued to the Sun will very nearly include his whole Body, as you see; and consequently it can't be seen by the Eye at C.

Euphros. I understand you pretty well as to that; but you seem to intimate that the Moon does not wholly and entirely eclipse the Sun's Body, when she is directly between us and him.

Cleon. No, she does not always; because her apparent Face or Disk is somewhat less than the apparent Face of the Sun, the Proportion being about 31 to 32; and therefore in the greatest Eclipse of the Sun, there will be some Time a very small *Annulus*, or Ring, on the Sun's Extremity not eclipsed, but visible, as you will by and by see.

Euphros. Besides the dark Shadow MCO, there is a fainter Sort of Shadow AMOB; pray, what am I to understand by that?

Cleon. That is called the *Penumbra*, or *partial Shadow*, because a Person any where on the Earth's Surface between C and A will see only a Part of the Sun's Face eclipsed; but so much a greater Part as he is nearer to C, or a less Part as he is nearer to A; for 'tis manifest when the Spectator is at A, he will see no Eclipse at all, but the whole Face of the Sun will there be visible, since the Line AME touches the Extremities of the Moon and Sun that are next to each other.

Euphros. I apprehend you very well; for since in any Part between C and A there will be more or less of the Sun's Light, the Shadow arising from the eclipsed Part will not be so dark as at C, where there is no Light, or next to none; and the same I see will happen all around the dark Shadow to the Distance of CA or CB.

Cleon. I am glad to see you understand the Nature of an Eclipse so well; you will as easily conceive that this penumbral Shadow will be darker about C, and less so towards the Extremities of the Cone A and B, were it becomes insensible.

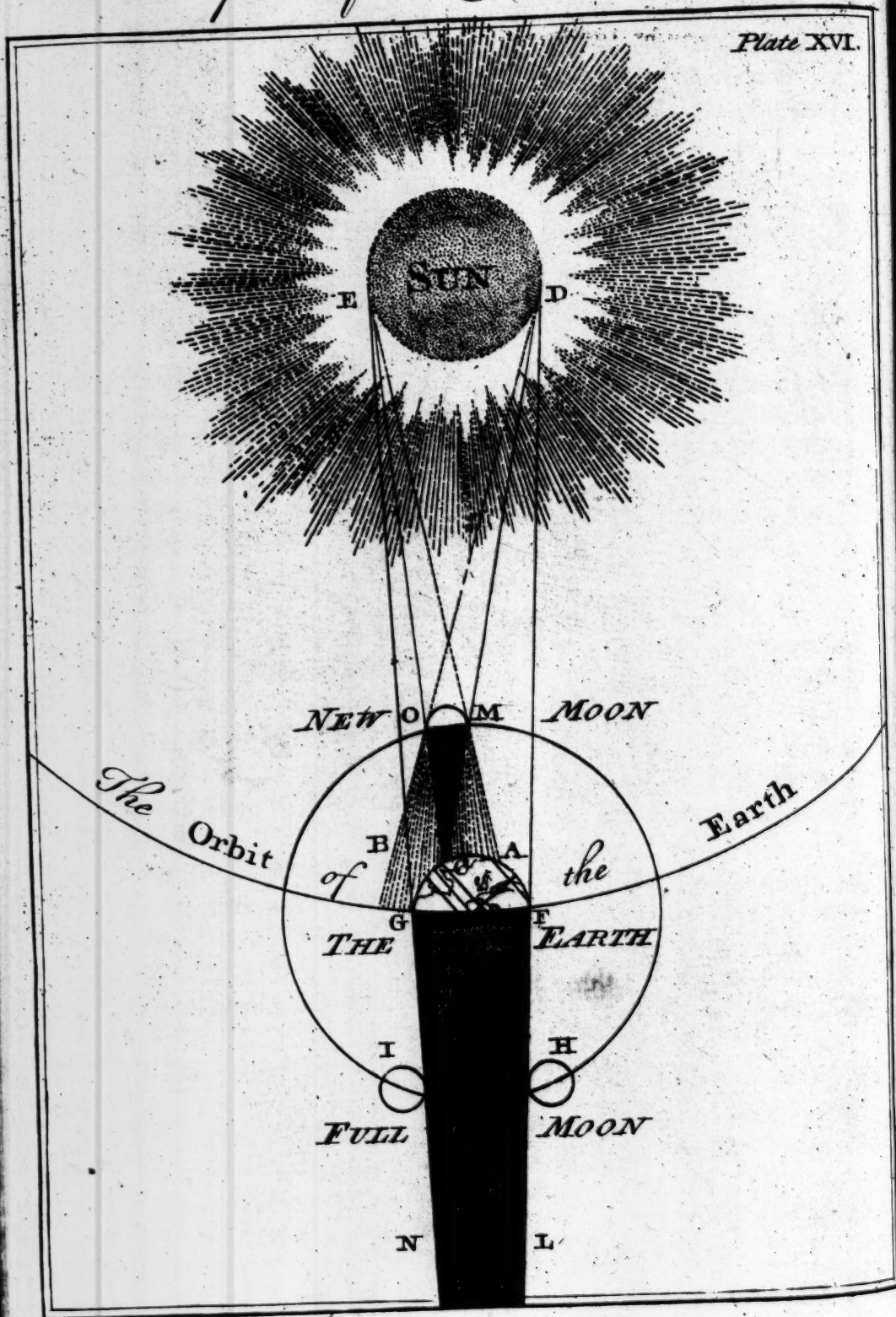
Euphros. I do, *Cleonicus*; but see, the Time is at Hand for the Eclipse to begin—It wants $5\frac{1}{2}$ Minutes by my Watch.

Cleon,



An Eclipse of the SUN and MOON.

Plate XVI.



and LADY'S PHILOSOPHY. 151

Cleon. Well, we are prepared for it, happen as soon as it will; I have fixed the Telescope in a proper Position for viewing it; and thereby you will see it in the Heavens. I have also darkened the Chamber, wherein you will see the Eclipse in Miniature very perfectly; and have so ordered it that you only need to step out of one Room into another to see both.

Euphros. Dear *Cleonicus* I am greatly obliged to you; but let me seat myself at the Telescope to observe the Beginning.

Cleon. Do so immediately; there is a Piece of black Glass before the Eye-Glass in the Telescope, through which you may view the Sun without hurting your Eyes.

Euphros. Very good, *Cleonicus*; let me view him——I see his glorious Face, and the several Spots which beautify it——there is yet no Appearance of an Eclipse.

Cleon. In half a Minute you'll see it.

Euphros. I do:——The Moon just touches him on the right Side——and covers a very small Part——let me see it in the Chamber——

Cleon. Look in——

Euphros. 'Tis just as I saw it at large in the Telescope, how beautiful it appears in that small Picture! But here it begins on the left Side, how is that?

Cleon. That is, because the Image of the Sun is inverted by the single Glass in the Scioptric Ball——See, there is a large Spot, which the Moon will presently hide,——view it in the Telescope——

Euphros. I will——The Moon is almost upon it——it disappears——also another small Spot below——she advances apace——the Sun is near one quarter eclipsed——I'll see it now in the dark Chamber——

Cleon. Do; I'll look thro' the Tube——Tell when you see a Spot just going to be hid——

Euphros. I will——the dark Circle is very near one on the upper Part——

Cleon. I see it,——speak when it disappears——

Euphros. The Moon just touches it——'tis gone.——

Cleon. I observed it the Instant you spoke; from hence you see how truly every thing in the Heavens is represented in the picturing of a dark Chamber.

Euphros. Very finely, indeed; I never observed an Eclipse with so much Pleasure and Exactness before — But see, methinks it begins to appear somewhat darkish, or else 'tis my Fancy —

Cleon. The Sun is now about two thirds eclipsed, and the Day-light begins to be sensibly diminished, and will be so in a few Minutes. —

Euphros. 'Tis darker than it was — I'll view the Sun again — he appears horned like the Moon in her last Quarter; — a great Cluster of Spots will be hid by-and-by. —

Cleon. They will so — the Darkness increases very sensibly — the Air seems obscured, you will quickly see the Stars —

Euphros. The Stars! Will it be so dark as to make them visible?

Cleon. Visible, yes, for a considerable Time; you will see Day converted into Night —

Euphros. Bless me, you make me shudder at the Thought. — The Spots are gone, *Cleonicus.*

Cleon. They are, I see, in the Image — see, from the Window, how the People stare and are surprized in the Street —

Euphros. Surpriz'd, and well they may; I believe they never saw it so dark in the Day-time before — How dark it is!

Cleon. It will be much darker by-and-by — in about three or four Minutes the Sun will be totally eclipsed —

Euphros. I find it cold too, as well as dark, *Cleonicus.*

Cleon. It is cold — see the Owl flying over yonder Meadow — she thinks 'tis Night —

Euphros. I see her — she hallows too — Hark! there's a general Murmur in the Streets — I heard one say he believed the World was going to be at an End —

Cleon. Very likely; they can't tell what to think of a Thing so very strange — See, yonder, a large Star appears —

Euphros. I see it — and many more — I believe the Sun is nearly quite eclipsed — The Birds chirrup, cry, and fly to the Hedges, as if very much frighten'd —

Cleon. They really are so — the Sun is now as much eclipsed as it can be —

Euphros. Then I now see the Ring, which you spake of, which the Moon leaves upon the Rim of the Sun —

Cleon.

Cleon. Thus you see the Moon appears less than the Sun — We are now in the *Dark Shadow*, which will not continue long — the Stars all appear —

Euphros. Look, see how the Beasts run under the Trees — what do the poor Creatures think!

Cleon. Think! they can't tell what the Matter is, — they know 'tis something very extraordinary — There has been many a Night not so dark as it is now.

Euphros. That I am sure of — well 'tis very surprizing —

Cleon. So it is, to see the two great Lights of Heaven in a manner both extinguished!

Euphros. The greatest Darkness is over I see — Pray, was it ever so dark in an Eclipse before?

Cleon. Yes, and rather darker sometimes; for it may now and then happen that at the Time of an Eclipse the Moon may be at such a Distance from the Sun as to appear somewhat larger than the Sun, and so will entirely hide his whole Face; whereas now a small Ringlet appears; and this is more properly called a *Central* than a *Total Eclipse* of the Sun.

Euphros. Do there often happen such very great and total Eclipses of the Sun?

Cleon. To some Part of the Earth or other there does; but not in any one Place; for in *England* I know not of above two total Eclipses that has happened in this or the last Century, viz. one in 1652, on *Monday, March 29*; and the other in 1715, 21st of *April*, when it was total about two Minutes of Time. The next great Eclipse happened in 1737, Feb. 18. Another pretty large one happened in 1748 on the 13th of *July*; besides these, we have no other to happen 'till the Year 1764, when more than five Parts out of six of the Sun's Diameter will be eclipsed.

Euphros. The Thing would not be so strange if it happened often. — The Sun recovers his Splendor apace — the Stars begin to disappear; and the Beasts retreat from their Coverts to the open Fields again.

Cleon. Yes, 'twill soon be Day once more, but a short one; these eclipsic Nights last but a little Time; they are scarce sufficient for a Nap —

Euphros. Pray, how large may the dark Shadow of the Moon be on the Part of the Earth which it sweeps?

Cleon. When at a Mean, it takes in the Compass of about 150 Miles; and when greatest it extends to 220 Miles.

Euphros. But what you call the Penumbral Shadow, I see, is vastly larger —

Cleon. Yes, it is so; it involves a Part of the Earth's Surface, no less than about *four thousand three hundred and ninety-seven Miles* over, at a Mean; and when greatest, it takes in about 600 Miles more; and therefore all People about us, to the Distance of near two thousand and five hundred Miles, will see the Sun eclipsed more or less.

Euphros. The Eclipse, I see, is nearly at an End: I do assure you, *Cleonicus*, I never spent $2\frac{1}{4}$ Hours with more Pleasure, and agreeable Surprise than now. — If you please, we will now go drink Tea, and then I shall trouble you with a few more Questions about an Eclipse of the Moon.

Cleon. With all my Heart, my *Euphrosyne*; you know nothing gives me a greater Pleasure than to satisfy your Enquiries about natural Things.

D I A L O G U E VI.

Of an ECLIPSE of the MOON.

Euphrosyne.

AS the Eclipses of the Sun which are visible to us must always happen in the Day-time, so those of the Moon must ever be in the Night, I conceive, *Cleonicus*.

Cleon. And very justly, Sister; for since an Eclipse of the Moon can never happen, but when the Moon is at full; and since the Moon is then in Opposition to the Sun, she will rise when the Sun sets; therefore no Eclipse of the Moon can be seen by us till after Sun-set. But the Moon may, and often does, rise and set eclipsed as well as the Sun.

Euphros. As I said before, I need not ask how an Eclipse of the Moon happens, for 'tis plain from the Scheme, that it is by the Moon's passing thro' the dark Shadow of the Earth FGLN,

Cleon.

Cleon. It is so; for the Earth at that Time coming between the Sun and Moon, and being much larger than the Moon, does cast so large a Shadow as often involves the Moon a considerable Time therein. According to *Lucretius*:

*So whilst the Moons their monthly Courses run
Within the Reach of Earth's dark shadowing Cone,
The Earth, revengeful, stops the streaming Light,
And hides the sick'ning Moon in Gloom of Night.*

Euphros. The *sick'ning Moon*. I think it is a very beautiful Metaphor on that Occasion.

Cleon. It is so; and it is only a Metaphor in the Poet; but the Vulgar among the Ancients did indeed believe that the Moon was actually *sick*, and laboured as in an Agony, and suffered a Kind of *Death*.

Euphros. Indeed! Pray, how came they by such a Notion?

Cleon. Their Superstition taught them to look on the Moon as the Goddess who presided over the Earth; and their Credulity (for the Ignorant believe any thing) made them fit Fools for Magicians and Inchanters to work upon; for these deceitful Wretches made them believe that it was in their Power to bring the Goddess down from her Sphere, and to torture her by muttering over some Charms and Incantations in Verse; to which *Milton* thus ironically alludes,

*Not uglier followed the Night Hag, when call'd
In secret riding thro' the Air, she comes
Lured by the Smell of infant Blood to dance
With Lapland Witches, while the lab'ring Moon
Eclipses at their Charms. ———*

And also *Butler*;

*Or putting Tricks upon the Moon,
Which by Confederacy are done.
Your antient Conjurers were wont
To make her from her Sphere dismount;
And to their Incantations stoop ———*

Yea

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Yea, so great was the Stupidity and Ignorance of the Ancients that even *Stesichorus* and *Pindar*, two Poets of great Name, were of this ridiculous Opinion, if we believe *Pliny* the Historian.

Euphros. And, pray, what did the poor deluded Mortals do in Behalf of their Deity, in such a disastrous Case.

Cleon. Do! You'll smile to hear they endeavoured to relieve her by ringing of Bells, sounding Trumpets, beating of brass Vessels, and making great Noises by hallowing, hooting, &c. to drown the muttering of Witches that the Moon might not hear them, and so receive no Harm. According to *Lee's* Imitation in his *Oedipus*——

— *The silver Moon is all o'er Blood:
A setting Crimson stains her beauteous Face;
Sound there, sound all our Instruments of War,
Clarions, and Trumpets, silver, brass, and iron,
And beat a thousand Drums to help her Labour.*

And *Medea*, boasting of her enchanting Power in *Ovid*, says,

*I cleave the Rocks, the knotted Oaks I break,
Remove the Forests, and the Mountains shake;
Force Earth to groan thro' all her hollow Caves,
And call the slumb'ring Ghosts from silent Graves.
Thee too, O Luna! from thy Sphere I call,
Tho' Brass relieves thee, and obstructs thy Fall.*

METAM. Lib. VII,

And thus *Tibullus*;

*Whene'er the Moon is forc'd from wand'ring Stars,
The Midwife Nations sound from far the Brass.*

And lastly, *Juvenal*, speaking of a loud scolding Woman, says pleasantly, that she alone was able to relieve the Moon out of the Labour of an Eclipse——

*Forbear your Drums and Trumpets, if you please,
Her Voice alone the lab'ring Moon can ease.*

And

And this strange and absurd Piece of Superstition is practised to this Day among the *Turks* and *Heathen* Nations with many and various ridiculous Ceremonies more than I have related, as Historians inform us.

Euphros. Well, you have entertained me with a pleasant Digression, which thoroughly convinces me how necessary it is for every one to study Philosophy who would have but a tolerable Notion of Things, and not be absurd and ridiculous in his Sentiments. But to return to the Matter — Pray, in how many Particulars does an *Eclipse of the Moon* differ from an *Eclipse of the Sun*?

Cleon. In the following, viz. First, The Moon is really and truly eclipsed by the Shadow of the Earth; whereas in a *Solar Eclipse* the Sun is not eclipsed, but the Earth by the Shadow of the Moon.

Secondly; An Eclipse of the Moon begins on the East Side or Limb, and ends on the West; but the contrary happens in a Solar Eclipse.

Thirdly; The Lunar Eclipses are more frequent to any one Place than Solar Eclipses. Because,

Fourthly; An Eclipse of the Moon appears from all Parts of the Earth to be the same as it really is; whereas an Eclipse of the Sun does not; but may be total in one Part, partial in another, and none at all to others, at the same Time.

Fifthly; But Solar Eclipses are more frequent with respect to the whole Earth than the Lunar ones; because the large Penumbra of the Moon can oftener fall on the broad Surface of the Earth than the small Globe of the Moon can fall into the conical Shadow of the Earth.

Sixthly; The total Darkness of a Lunar Eclipse lasteth $1\frac{1}{2}$ Hour, sometimes more; but that of a Solar Eclipse not above two Minutes.

These are the principal Differences of Eclipses, Solar and Lunar.

Euphros. I thank you, *Cleonicus*; you take a great deal of Pains with me; but one Question more. Pray, do you know the Dimensions of the Earth's Shadow at the Distance of the Moon?

Cleon.

Cleon. Yes; the Shadow of the Earth, where the Moon passes through it, is about 5900 Miles in Diameter, which is almost three Times the Diameter of the Moon.

Euphros. How long may an Eclipse of the Moon continue from first to last when greatest?

Cleon. From the Time of the Moon's Immersion into the Shadow at I, to the Time of her Emerision at H, is sometimes $3\frac{1}{2}$ Hours, and sometimes more; and the Time of total Darknefs is generally $1\frac{1}{2}$ Hour, as I told you before.

Euphros. I have a few more Questions concerning Eclipses that I want resolved; but on Account of the Visit we are to make this Evening must refer them to another Season.

DIALOGUE VII.

Of the Boundaries, and Number of Eclipses, and the Times of the Year when they happen.

Cleonicus.

I Remember, *Euphrosyne*, you told me, when we last discoursed of Eclipses, you had several Questions more to ask concerning them; if you'll now propose them I'll endeavour to give you Satisfaction in each Particular.

Euphros. One thing I have often wanted to know, why our Almanacks of several Years present us with different Numbers of Eclipses, sometimes they tell us we shall have *two*, sometimes *four*, and at other Times *six*: Also; why they happen at some certain *new* and *full Moons* and not at others; and other such like Matters.

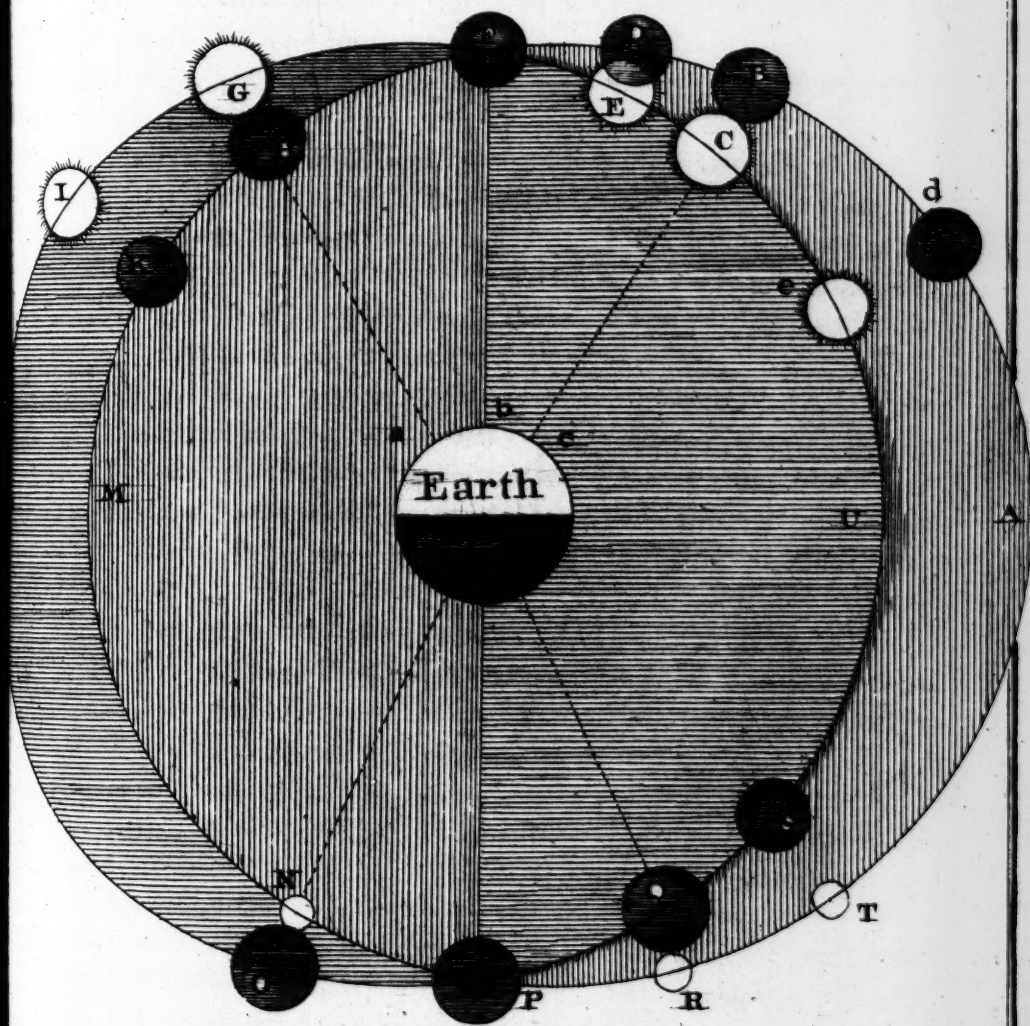
Cleon. That I may give you a good Idea of such Things, it is necessary you should conceive it by a little easy Instrument of two circular Pieces of Pastebord which I have here prepared, and contrived to shew the Nature of the Thing. One of these Pieces AFMP is to represent the Plane of the Moon's Orbit. —

Euphros. Very good! and what is the other design'd for?

Cleon.

The Limits of SOLAR and LUNAR Eclipses

Plate XVII.





Cleon. The other Piece UFLP, represents the Plane in which the Sun, or the Earth's Shadow appears to move in at the Distance of the Moon. For in the Firmament, the Sun seems to go in the same Tract very nearly with the Moon; and if the conical Shadow of the Earth were cut through, at the Distance of the Moon, that Section would appear a dark circular Space, and to move in the same Tract with the Sun.

Euphros. Well; and how then?

Cleon. Then the Edge of the circular Piece AFMP will represent the Orbit of the Moon, and that of the other Piece the Orbit of the Sun, or (in other Words) the Ecliptic, at the Distance of the Moon.

Euphros. So far I apprehend you pretty well; pray, proceed.

Cleon. In the last Place, you must know, that the Plane of the Moon's Orbit does not lie exactly level with the Plane of the Ecliptic, but one Half below it, and the other above it, just as you see me put these two Pictures of Pastboard together.

Euphros. I see your Meaning plain; the Half FAP lies below the Ecliptic, and the other Half FMP above it.

Cleon. Well, then the Distance between these Planes at their Extremities is called the *Latitude of the Moon*; that below the Ecliptic is the *South Latitude*, the other above it the *North Latitude*; because the Moon in describing the lower Part EAP is Southward of the Sun; but in the other Half FMP she is Northward of it.

Euphros. I understand you so far very well; pray go on.

Cleon. Also the Points F and P, where the Planes cross each other, are called the *Nodes*; and F the *Ascending Node*, because there the Moon rises above the Ecliptic, and is thus marked $\oslash$; the other, P, is the *Descending Node*, marked thus $\otimes$: And now having sufficiently explained the Instrument, it will be very easy to understand the Things you enquire farther of Eclipses.

Euphros. If so, I shall be very glad; and pray let me know when, or in what Part of the Moon's Orbit there may, and when there may not be an Eclipse?

Cleon. I shall satisfy your Enquiry first of *Solar Eclipses*; and therefore from what I have already said, you will easily conceive

ceive, that a Spectator at the Earth, *abc*, will view the apparent Faces of the Sun and Moon very nearly equal at the Distance of the Moon; and consequently the Moon journeying round every Month in her Orbit AFMP, and the equal Solar Disk moving round the Ecliptic UFLP, which two Orbits intersect each other at F and P; it must happen that in the Course of a Year the Sun will be seen in the Nodes F and P, at two different, and almost opposite Seasons of the Year; and will be for some Time so near them on each Side, that when the new Moon passes that Part of her Orbit, she must necessarily hide or cover either the Whole or Part of the Sun's Disk or Face, and so produce an *Eclipse of the Sun*, total or partial: For since the Inclination or Distance between the two Orbits grows less and less from AU, where it is greatest, towards the Nodes where it is nothing; so there must be a certain visible Latitude or Distance as at C, B, which is just equal to the Sum of half the Diameters of the Moon B, and Sun C; (because the greatest Latitude, AU or IM, far exceeds that Sum.) Again, since the visible Latitude BC is equal to the half Diameters of the Sun and Moon, the Moon in passing along will just touch the lower or Southern Limb of the Sun, but cover no Part of his Surface: Consequently any new Moon before the Point B, as at *d*, will have such a Latitude from the Sun at *e*, as will exceed the Sum of their half Diameters, and so will be seen to pass at some Distance below the Sun, and not touch it.—But if the new Moon appears nearer to the Node F, as at D, where her Latitude from the Sun at E is less than the said Sum of the half Diameters of the Sun and Moon, then the Moon will be seen to pass over a Part of the Sun's Disk, and so cause a *partial Eclipse* of the Sun where it is visible.

Once more; if the new Moon happens in the very Node itself, as at P, the Sun being there also, the Moon then having no Latitude must necessarily pass over the whole Disk of the Sun, and so produce a *central and total Eclipse of the Sun*.

Lastly; New Moons on the other Side of the Node F, to the same Distance G H, will produce Eclipses, more or less, on the upper or northern Part of the Sun; but at H the Sum of the half Diameters and visible Latitude being again equal, the Luminaries will there but just touch each other; and in all Parts
far-

farther from the Node, as at K, there will be no Eclipse possible; for the Moon will then pass above the Disk of the Sun.

Euphros. It is all very evident; and therefore I presume the Points B and H in the Moon's Orbit are what you call the *ecliptic Boundaries*, or *Limits of Solar Eclipses*.

Cleon. Yes, they are so; and now with Respect to *Lunar Eclipses*, we must turn our Eye to the opposite Parts of the Orbits on each Side the Node P, where we shall view the *Full-Moon* in her Orbit, and the Section of the Earth's Shadow at the Distance of the Moon's Orbit in the Points O, P, Q, S.

Now, in the first Place, let us consider that if the *Full-Moon* happens at N or R, where the Earth's Shadow passing by just touches it, then in any Point between N and R, the said Shadow will more or less involve the Moon, and so cause a *Lunar Eclipse* in a greater or lesser Degree; and therefore those two Points, N and R, in the Lunar Orbit, where the Sum of the half Diameters of the Moon and Earth's Shadow is equal to the true Latitude of the Moon, are the *Boundaries* or *Limits of Lunar Eclipses*, on each Side the Node P.

Again, in the second Place; the nearer the Moon is to the Node P, the greater will be the Eclipse, and therefore greatest of all, and central, in the Node itself, where the Shadow of the Earth is near three Times greater than the Moon, as I formerly told you.

Euphros. The Manner of explaining the Boundaries of a *Lunar Eclipse* I see is the same nearly as that of the Solar ones, and as easily understood. But unless I could tell which were greatest, the *Sum of the half Diameters of the Sun and Moon*, or of the *Shadow and Moon*, I can't tell which would be greatest, the *Limits of a Solar or Lunar Eclipse*.

Cleon. Though the latter Sum be in itself greater than the former, yet the former, with Respect to the *visible Latitude* of the Moon, is greater than the latter, in Regard of her true *Latitude*; and therefore the *Limits of a Solar Eclipse exceed those of a Lunar one*.

Euphros. I should be glad to know in what Time the Sun moves over the ecliptic Limit CG.

Cleon. These Limits are somewhat variable; but when CG is least, the Sun takes up about 28 Days in passing over it, and 32 Days when greatest.

Euphros. And pray what is the Time between one new Moon and another?

Cleon. Twenty-nine Days and an half.

Euphros. Why then, when the Limit CG is greatest, there must necessarily be an Eclipse of the Sun during his Stay within that Limit; but when it is least, I perceive it is possible there may be no Eclipse of the Sun that Node.

Cleon. 'Tis indeed possible there may not; but the Chance there will not is so very great, that it was never known to happen, I believe. On the other Hand, when the Limit is least there is *one* Eclipse very certain, and there may be *two* when greatest; and this sometimes happens, as in the Year 1736, 1743, &c. But these twin Eclipses are very small, and almost always to us invisible.

Euphros. Of all this I conceive the Reason pretty well; and now for the other Node: Pray how long is the Shadow of the Earth within the *Lunar Limit* O Q?

Cleon. This Limit is also variable; and when greatest, the Shadow passeth it in 24 Days; and when least, in 19 Days.

Euphros. Then since from Full Moon to Full Moon there is 29 Days and an half, if the Full Moon should happen in the Beginning of the Limit, as at N, before the Moon could again return to the same Node, the Shadow would be past the other Limit Q; and so there would be no Eclipse of the Moon, in such a Case, that Node, even when the Limit is the greatest of all.

Cleon. Very well observed, *Euphrosyne*; nor can there ever be two Lunar Eclipses together at the same Node, when the Limit is greatest; so that upon the whole you see there can be but one Eclipse of the Moon within the Lunar Limits, and sometimes none at all.

Euphros. Then I see 'tis possible, that in some Years there may be no Lunar Eclipse at all.

Cleon. Yes, it is; and thus it happened in the Years 1734, 1738, 1745, 1752, the present Year 1756, and 1763; for in these Years there was no Eclipse of the Moon; and but two of the Sun, and both invisible to us, except that of *August* the 3d, 1738,

Euphros.

Euphros. We find by Experience that the Solar and Lunar Eclipses happen both at the same Times of the Year, which is also evident from the Instrument.

Cleon. It is so ; for the new Moon, which obscures the Sun in the Solar Limit, is itself eclipsed by the Shadow of the Earth at the Lunar Limit, when it is next at Full.

Euphros. I understand you very well ; and I farther observe, that as the Nodes F and P are in opposite Points of the Orbit, so after half a Year, the Nodes will change their Nature, and that which is now the *Solar Node* will then become the *Lunar* ; and the *Lunar Node* that now is, will then become the *Solar Node*, and will be the Season of Eclipses again.

Cleon. It will not be quite half a Year between, because the Sun, for Instance, may be eclipsed at the End of one Limit, as at G, (as in the Year 1732, Dec. 6.) and at the Beginning of the other at O, (as May 2, 1733) in which Time there intervened not above 147 Days, which is short of half a Year by 35 Days. Yea, the Sun may leave one Limit, and arrive to the next in about four Months and an half, as in the Year 1740 the Sun was eclipsed Jan. 17, and again in June 12 ; and another Reason for this is, that the Nodes F and P are not fixed, but move in a retrograde Manner, so as that the distant Node is carried towards the Sun, and they meet near ten Days sooner than if the Node were fixed.

Euphros. Well, I am not now so much at a Loss to guess the Reason why we have in different Years a different Number of Eclipses ; why one Year *four*, another Year *two*, and a third Year *five* or *six* ; and also the Reason why they happen at such and such Intervals and Seasons of the Year : This Doctrine of Nodes and Limits has given me the *Rationale* of Eclipses beyond whatever I expected ; and now to be plain with you, I am got to a *ne plus ultra*, for I know not what further to ask or say on the Subject of Eclipses.

Cleon. We have pretty well exhausted the Subject, indeed, *Euphrosyne*, and I shall only observe to you next, that the Year 1740 had six Eclipses in a very peculiar Manner ; for in those Years wherein six Eclipses happen, there are generally *two of the Sun and one of the Moon* at each ecliptic Season ; but in that Year there were three ecliptic Seasons, or the Luminaries came
three

three Times within the ecliptic Limits, and each of them suffered an Eclipse each Time; so that in that Year there were three Eclipses of the Sun, and three of the Moon; a Thing which very rarely happens. But Eclipses, like all other Things, in a long Course of Time, undergo a great Variety of Mutations and Changes, in the Circumstances we have now been considering.

*Thus I've the Motions taught of STARS above,
Of SUN, and MOON, and by what Cause they move;
And how eclipsed they loose their gaudy Light,
And spread o'er all an unexpected Night,
As if they wink'd, and then with open Eyes
View'd all again, and clear'd the lower Skies.*

Creech's Lucretius, Book V.

DIALOGUE VIII.

*Reflections on the Immensity of the Universe, and of
the Plurality of Worlds.*

Euphrosyne.

THE Conversations which have passed between us of late have opened a new and strange Scene of Things to my Mind, and given quite a new Turn to my Thought; I used to fancy the Earth on which we live, and the visible Lights of Heaven were all the Creation, the Whole of the Universe; nor did I ever imagine God had more than once said, *Let us make Man*. I thought we had held the second Class of created Beings, and must acknowledge Superiority only to Angels. But what can we think of ourselves, *Cleonicus*, if every Planet be a World, and every Star the central Sun of a System? If every System be inhabited, and those Inhabitants various as the Globes they live on!

Cle.

Cleonicus. We can't certainly tell what to think, my *Euphrosyne*; the *Idea* is too grand for human Comprehension; even Reason, Nature, and Analogy here are but blind Guides; they conduct us with Certainty but a little Way in the Abstrusities of infinite Creation; and e'er we have passed, as it were, the Threshold of the Universe, we are lost and confounded. With the Poet we may say —

*Now had th' eternal Architect supreme,
In Amplitude stretch'd out this wond'rous Frame;
Equipt magnificent, the House of God,
Through Heighth and Depth, his boundless, blest Abode;
One House, one World, one Universe divine,
Where countless Orbs thro' countless Systems shine.
Systems! which view'd throughout the Circuit wide,
Or lost — or scarce the pointed Sight abide.
(Thro' Space immense, with Diminution seen)
Yet boundless, to those Worlds that roll within;
Each World as boundless, to its native Race,
That range, and wanton thro' its ample Space;
Frequent thro' Fields, thro' Clouds of Fragrance stray.
Or skim the wat'ry, or ethereal Way.*

Universal Beauty.

Euphros. The Poet's Reflections are certainly just; they do indeed inspire us with noble and august Sentiments of the divine Being: He has made, and by his Providence governs, not one, but an *Infinity of Worlds*! How narrow must their Conceptions be, who imagine our Earth contains the whole of the rational Species, or that Heaven is to be replenished with Colonies from this little Spot alone!

Cleon. Very true, Sister; our Earth's a little Spot indeed, and inconsiderable in Comparison of the more noble Parts of this, much more of those of innumerable other Systems. In Regard of which, Mr. *Baker* thus expostulates with opinionated Man.

*What is this Earth, of which thou art so proud?
Lost and unknown in the more glorious Crowd,*

A Point

*A Point it scarce appears.—E'er it begun,
The Rest their Courses have —
And shall, when it's no more, to endless Ages run.*

Universe. }

Euphros. Our Earth to be sure can be considerable to no Part of the Universe but ourselves, and perhaps to the Inhabitants of the Moon, who behold it as a very large and bright Moon; but as to all other Worlds, *Mercury, Venus, and Mars* excepted, the Existence of our Earth, (I find by what you have said) is neither known or suspected by them: And if the Earth be not, then surely its Inhabitants must be absolutely unknown, and inconsiderable with Respect to the Universe.

Cleon. Your Observation is very just, *Euphrosyne*; and yet you see what an high Value Mankind are apt to put upon themselves. Because we are superior to *Brutes*, we imagine we are next to *Angels* in the Scale of Beings: Because we have Dominion over the Fowls of the Heavens, and Beasts of the Earth, we invade the Stars, and claim a Sovereignty over all the celestial Worlds, because this terrestrial Spot is put under his Feet. But how absurd, how ridiculous is our Vanity, in thinking all Things made for our Use, when the utmost Use we make of any Thing about us is but very trifling: Of all the numberless Species of Animals, how few do we know? how few do we use? how many do we fear? how many do we fly from? Again, do we boast the Use of the Sun? so may the most contemptible Insect: Does the Moon light up the Night for us? so it does for the Owls, &c. also. If all the Planets of our System were annihilated, few besides Astronomers would miss them. Lastly, who is the Man that can say any one single Circumstance of his Life was ever affected or altered by any one, yea, all of the fixed Stars? The Pride, therefore, and Arrogance of Man in challenging to himself the Empire of the Universe, are handsomely lashed by the Satire and Irony of the following Verses.

*Where's now thy Pride, which lately dar'd to say,
The Stars were only made to light thy Way,
And all the Universe thy Pleasure to obey?*

What }

and LADY'S PHILOSOPHY. 167

*What impious Madneſs urg'd thee on to call
Thyſelf the ſole and ſovereign LORD of all?
If ſuch thou art, let ſome plain Proof be ſhown,
And make thine Empire o'er thy Vaſſals known.
Bid the Sun ſhine; command the Winds to ceaſe:
Make the Rains fall; or chide the Seas to Peace.
What! are theſe deaf?—Once more exert thy Sway:
Try which of all thy Subjects will obey:
Enjoin the Tyger to refrain from Blood,
Or bid the Crocodile provide thy Food.
Theſe know their King, perhaps, and will comply.---
Hail, mighty Lord!--What! does the Monarch fly?
Unhappy Prince! whoſe impotent Command
The meanest of thy Vaſſals dares withſtand,
And wreſt the Sceptre from thy feeble Hand.*

Univerſe.

Euphroſ. Your rehearſing thoſe Lines brings to my Mind a
Fable of the late ingenious Mr. Gay, of the *Man and Flea*, to
this Purpoſe——

*What Dignity's in Human Nature,
Says Man, the moſt conceited Creature,
As from a Cliff he caſt his Eye,
And view'd the Sea and arched Sky!
The Sun was ſunk beneath the Main,
The Moon, and all the ſtarry Train,
Hung the vaſt Vault of Heav'n. The Man
His Contemplation thus began.*

*When I behold this glorious Show,
And the wide wat'ry World below,
The ſcaly People of the Main,
The Beaſts that range the Wood or Plain,
The wing'd Inhabitants of the Air,
The Day, the Night, the various Year,
And know all theſe by Heav'n deſign'd
As Gifts to pleaſure Human Kind.
I cannot raiſe my Worth too high;
Of what vaſt Conſequence am I!*

Z

Not

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*Not of th' Importance you suppose,
Replies a FLEA upon his Nose;
Be humble, learn thyself to scan;
Know, Pride was never made for Man.
'Tis Vanity that swells thy Mind.
What! Heav'n and Earth for thee design'd!
For thee!—made only for our Need;
That more important Fleas might feed.*

Cleon. The great Mr. Pope too makes [a perfect Jest of the giddy, humourous Creature, Man. —

*Created, half to rise, and half to fall;
Great Lord of all Things, yet a Prey to all.
Sole Judge of Truth, in endless Error hurl'd;
The Glory, Jest, and Riddle of the World.*

Yea, he makes the Angels admire the greatest Man no other-wise than we do a Monkey, in these Lines:

*Superior Beings, when of late they saw
A mortal Man unfold all Nature's Law,
Admir'd such Wisdom in an earthly Shape,
And show'd a Newton, as we show an Ape.*

Essay on Man.

Euphros. But, pray *Cleonicus*, do not the Poets carry the Jest too far in thus ridiculing Mankind? Ought we not to have an higher Esteem for Man, whom the Scripture makes the constant Subject of God's particular and distinguishing Providence, Care, and Goodness.

Cleon. Doubt not, my *Euphrosyne*, but Mankind is the special Care of God and Heaven; nor do any of the Poets or Philosophers dispute, or question that: 'Tis the Pride, Presumption, and Self-Conceit, not the Dignity of Man, which they lampoon. 'Tis one Thing to suppose Man the Care of God, and another to suppose him *only so*: We know there are Globes in our System vastly superior to ours, and there may be in other
Syl-

Systems, others vastly superior to these; if, therefore, the Inhabitants of these are equally superior to each other, as is reasonable to suppose, then there are other Species of rational Beings as much superior to us, perhaps, as Angels are to them, or we to Apes or Monkeys. The Scale of rational Beings does in all Probability admit of various Gradations, among which those of Brute Nature are the lowest.

Euphros. Indeed, I can't say but it seems a little absurd to suppose infinite Wisdom should exhibit such a wondrous Variety of Natures, Kinds, Forms, Sizes, Perfections, &c. in the inferior and more unworthy Part of the Creation, and be content with giving one Specimen only of a better Sort.

Cleon. And that too in one Point only, *viz.* the Power of the contemplative and reasoning Faculties. For 'tis well known, that, with respect to any Sense of the Body, Man is exceeded by some one or other of the irrational Tribes. The Mind is doubtless a noble Principle, but should it be thought strange to suppose that it is capable of various and different Degrees of Perfection? Or that there should be Beings, who possess all these superior Degrees, and are therefore of a more exalted Nature than ours?

Euphros. Well, granting what Variety of reasonable Beings you please, I presume you allow they are all designed for Heaven and Happiness in another World: But, pray *Cleonicus*, what becomes of irrational Creatures when they die?

Cleon. By Nature only, we know but little of our own future State, and of Course but little or nothing of theirs. 'Tis sottish to imagine that they were made to answer no End, but Man's Luxury, Diversion, or Use. No doubt, but in the Creator there was one uniform Design of Happiness and Good intended for the Whole, and to be enjoyed by every Creature, in Proportion to the Perfection of its Nature. But of what Sort or Kind this general Felicity is, and where and when to be enjoyed, is Part of the Knowledge concealed from us. That there are Strokes of surprising Wisdom and Design in the meanest Animal we well know, and shall see more of in our future Conversations; and also, that there is a mutual Relation, Dependence, Harmony, and Connection in all the animated Orders

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of Beings; which plainly prove, that each Order, and every Individual, is of some Importance and Concernment to the Whole, as well as Man. According to the Poet's fine Simile,

*Like some grand Building is the UNIVERSE,
Where every Part is useful in its Place;
As well the Pins which all together hold,
As the rich Carvings, or the glowing Gold.*

Universe.



The

The Young GENTLEMAN and LADY'S
P H I L O S O P H Y.

P A R T III.

D I A L O G U E I.

The Doctrine of the SPHERE; or, a general Description of the Circles thereof.

**Cleonicus.*



WELL, my *Euphrosyne*, I make no Question but the Conversations we had when I was with you last, have made a notable Impression on your Mind, and supplied you with Matter of ample Meditation and Amusement.

Euphrosyne. Greatly so, in each Respect, dear *Cleonicus*; and so agreeable were those Studies, and so advantageous to my Mind and Understanding, that I shall ever reflect with Pleasure and Gratitude on the Care and Pains you then took to instruct me in those more than *human* (I may truly say *divine*) *Speculations*. You are a Stranger to the longing Expectation I have had for your Return, that I might have the Happiness of making a farther Progress and Proficiency therein.

Cleon. You speak in most engaging Accents; we will now apply every Opportunity to that Purpose; and as we then contemplated the Heavens in a natural and practical Way; so now we will farther consider the Advantages Art has supplied us with
to

* Now returned again from the University, where he is supposed to have been to pursue his Studies since the last Dialogue was finished.

to make those Things still more easy and practically useful. To which End we have three excellent Instruments contrived, viz. the ARMILLARY SPHERE, the ORRERY, and the GLOBES.

Euphros. I should much delight to be acquainted with the Nature and Uses of these Instruments, *Cleonicus*.

Cleon. That you will attain with great Ease; for there is nothing in them which a Genius much inferior to yours is not capable of apprehending.

Euphros. No Compliments, I beg of you, *Cleonicus*; I shall put you to prove your Words; for, if I can once understand these Machines, I shall have a great Opinion of myself as an Astronomer.

Cleon. And justly you may; nor will you then be the first Woman who has understood Astronomy well. Astronomy is a noble Science, worthy the Fair-Sex, and highly deserving the Encomium of the Poet.

Astronomy! hail, Science heavenly born!
Thy Schemes the Life assist, the Mind adorn.
Thy Aids the Heaven's seal'd Volumes wide impart;
And taught the Seaman first his useful Art;
Gave changing Seasons their determin'd Space,
And fix'd to Hours and Years their measur'd Race.

Euphros. So useful a Science urges me with Impatience to the Study of it; and, pray, which of the afore-named Instruments do we first begin with, to employ the remaining Hours of the Day?

Cleon. The ARMILLARY SPHERE, by the Knowledge of which you will naturally be led to the understanding of the Orrery and the Globes, on which you may practise all the useful Problems of Astronomy.

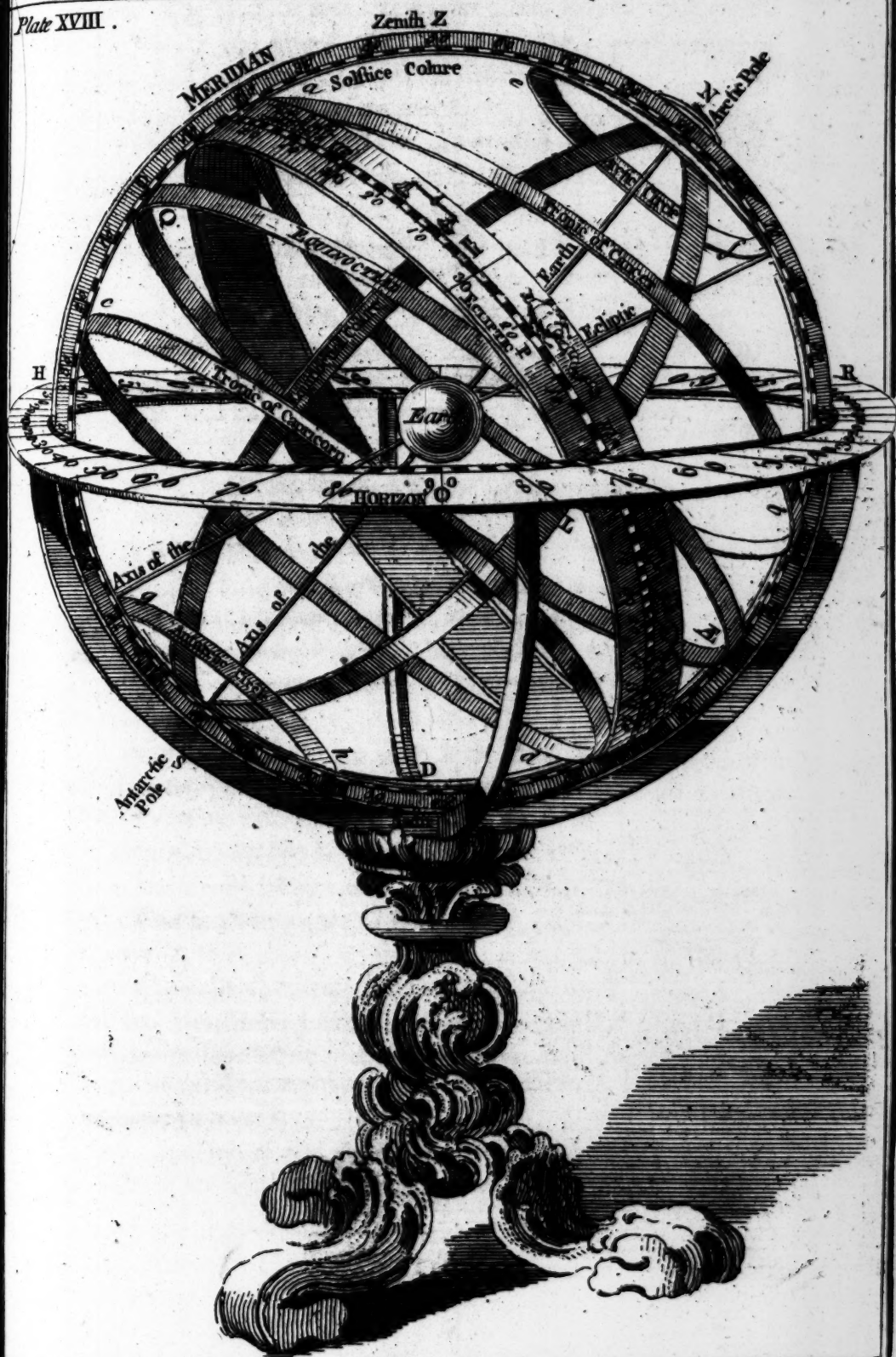
Euphros. Pray what is that you call the *Armillary Sphere*?

Cleon. I will presently shew you; I have bought one at London, as I came home, which cost me 20 Guineas, on Purpose to give you the better Idea of such Things as may prove the future Subject of our Speculations.—Here it is, Sister.

Euphros. A fine and curious Machine, indeed! But I see nothing

The Armillary Sphere

Plate XVIII.





thing but Circles variously connected together; pray, what am I to understand by them?

Cleon. You will see more hereafter; but we will first consider the Nature and Use of the Circles; a due Understanding of which is the Ground of all practical Astronomy.

Euphros. That's doubtless the Case; but a Parcel of bare Circles seem an uncouth Subject for Study; they seem so variously combined and intermixed, that I fear I shall never understand them.

Cleon. So I remember you once said of the various Conjugations and Kinds of Verbs in the *French Grammar*, and yet you have found, that nothing but Attention and Resolution was necessary to make you a perfect Mistress of them. The like you will find of this Study, which is much easier: I shall only repeat the Words of *Manilius*, to encourage you thereto.

*A subtle and surprising Task is shown;
Much have I past, yet still you lead me on.
These Things seem dark, whilst I the rest explore,
Enjoy my Precepts, and complain no more.
'Tis God you search for, by my Aid you try
To climb, and view the Inside of the Sky;
Confin'd by Fate, you search its boundless Sway,
And seek to know the Laws you must obey:
The narrow Bounds of your own Breast you pass,
Enjoy the World, and rove in the vast Space:
Painful, but always noble Things are hard,
Great is the Task, but equal the Reward:
Nor let the various Maze thy Thoughts repress,
Enter, and you are certain to possess.*

Book IV.

Euphros. I do not in the least despond; I only wish your Patience, *Cleonicus*, may hold out with mine. To make a Beginning on this Instrument, therefore, pray tell me why it is called an *Armillary Sphere*?

Cleon. Because of the various Circles of which it is composed, which are like so many *Rings* or *Hoops*, which in *Latin* are

are called *Armilla* in general; though this Word properly signified a Bracelet, an Ornament formerly worn on the Arm, and given by Captains to their Soldiers, and by such as held any Post, &c. Hence you see the Propriety of the Name.

Euphros. I do; and must next ask you what this Sphere is designed to represent in general?

Cleon. This Sphere, by its real Circles, represents the imaginary Circles of the concave Expanse of the Sky, by which Astronomers divide the Heavens into the same Parts or Portions, as you see these Circles divide the Sphere.

Euphros. I suppose you mean, if my Eye could be placed in the Center of this Sphere, I should see its Circles upon, or against those very Parts of the Heavens where those imaginary Circles of the Astronomers are supposed to be.

Cleon. Most happily conceived, my *Euphrosyne*; your Genius is turned for the Science.—The Sphere you observe is moveable within the Frame, and the large Circle (H O) supported thereby; which Circle, you see, with some others, are graduated, or divided into their proper Degrees.

Euphros. I take notice of those graduated Circles; but must confess I have but an imperfect Notion of those Divisions and their Uses, and should be glad to have them farther explained to me.

Cleon. To understand that aright is a fundamental Article; in order to which you must know, that a Circle is generally divided into four equal Parts or Quarters, called *Quadrants*, and each of these Quadrants is again divided into 90 equal Parts, called *Degrees*, as you see is done on this broad Circle; so that the whole Circle contains four Times 90, or 360 Degrees.—Again, each Degree is supposed to be subdivided into 60 equal Parts, called *Seconds*, and each Second into 60 others, called *Thirds*; and so on. But these last Divisions are too small to be actually made; and therefore a Degree is generally divided but into Halves and Quarters; that is, at every 15th Minute: But I have formerly acquainted you with this Manner of dividing a Circle, and need not again repeat it to my *Euphrosyne*.

Euphros. I understand you well, and those Degrees, I see, are numbered at every 10th Division; but I also observe, this Method

thod of numbering Degrees is not the same in all the graduated Circles of this Sphere.

Cleon. No, it is not; but differs in almost all of them, according to their different Nature and Use.

Euphros. Pray, how many Kinds of Circles are there? And what are their Names?

Cleon. All the Circles of the Sphere are but of two Sorts, viz. *Great and small Circles.* The greater Circles divide the Sphere into two equal Parts, or *Hemispheres*; and lesser Circles divide it into two unequal Parts, or *Segments.*

Euphros. How many are the great Circles of the Sphere?

Cleon. They are in Number six. Four of which are graduated, viz.

1. The *HORISON*, (H O R) which is this broad Circle, supported by the Frame within which moves

2. The *General MERIDIAN*, (H Z R D) which is this upright, graduated Circle, standing at right Angles to the Horizon; and within this moves the Sphere itself.

3. The *EQUINOCTIAL*, (Æ Q) which divides the Sphere into the *Northern and Southern Hemispheres.*

4. The *ECLIPTIC*, which is this large Circle, on which you see the Characters of the 12 Signs, and which cuts the *Equinoctial* in two opposite Points at the Horizon.—The other two are called *COLURES*; the first of which is called

5. The *Equinoctial COLURE*, which is the great Circle that passes through those two Points of the *Equinoctial*, where the *Ecliptic* intersects it.

6. The *Solstitial COLURE*, which is that great Circle you see just under the *General Meridian*; to which, and the other *Colure*, all the other Circles are fixed.

Euphros. So far I understand you very well: But now tell me which, and how many are the *lesser Circles* of the Sphere?

Cleon. They are four, viz. Two *Tropic*, and two *Polar Circles.*

1. The *Tropic of Cancer*, (a b) which lies parallel to the *Equinoctial* on the North Side, at the Distance of $23\frac{1}{2}$ Degrees, and touches the *Ecliptic* in the Beginning of *Cancer.*

A a

2. The

2. The *Tropic of Capricorn*, (*de*) which is situated, you see, at the same Distance from the *Equinoctial*, and parallel to it, on the South Side; touching the *Ecliptic* in the Beginning of *Capricorn*.

3. The *Arctic Circle*, (*ef*) parallel to the *Equinoctial* on the North, at the Distance of $66\frac{1}{2}$ Degrees.

4. The *Antarctic Circle*, (*gh*) which, you see, is parallel to, and at the same Distance from the *Equinoctial* on the South Side.—And thus you have the Names of the principal Circles of the Sphere.

Euphros. I thank you, *Cleonicus*: But there is that strait, curious Rod or Wire in the Middle of the Sphere, about which it turns; is it not what you call the *Axis of the Sphere*?

Cleon. Yes, *Euphrosyne*, it is; and it represents the Axis of the World, and the two Extremities thereof, (N and S) are called the *Poles* of the World; the former (N) the *North Pole*, which is above our Horizon; and the latter (S) the *South Pole*, below the Horizon.

Euphros. But this small Circle, fixed on the Meridian about the North Pole, I presume, you call the *Hour-Circle*; from the Hours I see engraved thereon, and the Hand on the Axle, pointing to them.

Cleon. You judge aright, 'tis called the *Hour-Circle*; and is rather an Appendage to the Sphere, than a Part of it: The Use of which, and of all the Circles of the Sphere, great and small, we will more fully consider, and apply, in the next ensuing Opportunities. The Day-light being too far gone to admit any Thing farther on this Subject at present.

DIALOGUE II.

Of the HORIZON, and its various Uses.

Euphrosyne.

YOU gave me Yesterday an Account of the Spheres, and the Names of the Circles which compose it, *Cleonicus*; I shall

shall be glad to have a more distinct and particular Explanation of the Nature and Use of those Circles, that I may the more compleatly comprehend the Design of the Machine.

Cleon. I'll now begin to inform you of the *Name, Nature,* and *Use* of all the Circles; how they divide the Sphere; and the Terms of several Points and Parts of the Machine derived therefrom.—And first of all, let us consider this broadest Circle, the *Horizon*.

Euphros. With Pleasure I attend you, *Cleonicus*; pray then, whence has it the Name? And what does it import?

Cleon. The Word is derived from the *Greek*, and the Use of the Circle is contained in its Name; for it comes from a Word which signifies to *bound, limit, or terminate*; as the *Horizon* is appointed to shew that Circle in the Heavens, which *bounds or terminates* the Sight of the Spectator any where situated on the Earth.

Euphros. I suppose you mean, that distant Boundary of our Sight, where the Heavens and the Earth seem to join all around us, as it appears from the Top of an high Mountain or Tower.

Cleon. The very same, *Euphrosyne*; 'tis that imaginary Circle which intercepts from our View the Sun, Moon, and Stars, each Night; and when they descend below it, we say, *they are set*; as on the contrary, each Morning, when they appear above it, we say, *they rise*.

Euphros. How far is this Circle distant from us in the Heavens?

Cleon. It is every Way distant from the Point over our Heads in the Heavens just 90 Degrees; and therefore divides the Heavens into two equal Parts, called the *Upper* and the *Lower Hemispheres*.

Euphros. By the upper Hemisphere, I suppose, you mean all that Part of the Heavens which is open to our View; and by the under or lower Hemisphere, all that Part which is hid from our Sight.

Cleon. Very right, Sister, I do: And the two Points, (Z and D) which are equally distant from the Horizon on every Part above and below it, are called the *Poles of the Horizon*; and further, this which is above it, (z) and over the Head of

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the Spectator, is called the *Zenith*, as that (D) which is under his Feet is called the *Nadir*. Of this great Circle *Manilius* thus sings:

*To find the spacious Line, cast round thine Eyes,
And where the Earth's high Surface joins the Skies,
Where Stars first set, and first begin to shine,
There draw the fancy'd Image of this Line.
Which Way so'er you move, 'twill still be new;
Another Circle opening to the View;
For now this half, and now that half of Sky,
It shews its Bounds still varying with the Eye,
This Round's terrestrial, for its Bounds contain
That Globe, and cut the Middle with a Plain;
'Tis call'd the Horizon, the Round's Design,
For 'tis, to bound, gives Title to the Line.*

Astron. Book I,

Euphros. The Poet intimates what I was just going to observe, viz. that this Circle must *always be variable and new*, according to the different Situation of the Spectator on the Surface of the Globe, or Sphere.

Cleon. Very true, *Euphrosyne*; every Person has an Horizon peculiar to himself. Thus the People of *Paris* have a different Horizon from that of the People at *London*, or *Madrid*; their visible Hemisphere extending more to the South than that of the former, and less than that of the latter. All which I shall more fully explain to you on the terrestrial Globe.

Euphros. But, pray, what is this other Circle on the outer Part of the Horizon, marked all round with Letters?

Cleon. This Circle is called the *Compass*; it is of great Use at Sea; and also in the Sciences of Astronomy and Geography; for which Reason it is fixed on the Horizon of Spheres and Globes.

Euphros. What are those various Divisions in it, by which the Letters stand?

Cleon. They are called the *Points of the Compass*; and are 32 in Number, each containing 114 Degrees. Four of which are called

called the *Cardinal Points*, and are marked with the first Letter of their Names, viz. S, the *South*; W, the *West*; N, the *North*; E, the *East*. These four principal Points are sometimes called the *four Winds of Heaven*. They divide the Horizon, you see, into four Quarters, in each of which are *eight Points*.

Euphros. What are the Names of these intermediate Points?

Cleon. They receive their Names from their relative Distances from the four Cardinal Points, in each Quarter respectively; which Names are denoted by the initial Letters also.

Thus in the Quarter between the *South* and *West*, the Points are denominated as follows:

- | | |
|----------------|----------------------|
| 1. S. | SOUTH. |
| 2. S. by W. | SOUTH by WEST. |
| 3. S. S. W. | SOUTH-SOUTH-WEST. |
| 4. S. W. by S. | SOUTH-WEST by SOUTH. |
| 5. S. W. | SOUTH-WEST. |
| 6. S. W. by W. | SOUTH-WEST by WEST. |
| 7. W. S. W. | WEST SOUTH-WEST. |
| 8. W. by S. | WEST by SOUTH. |
| W. | WEST. |

After the same Manner, you see, the Points in the other Quarters are named as denoted by the Capital Letters.

Euphros. I understand you perfectly well, as to that; but what is the Use of these Points?

Cleon. By them we usually distinguish the Course of the Winds and Clouds, and give them their proper Names; thus if the Wind blows from the *North-East* Point, we say it is a *North-East Wind*; and the Course of the Clouds we say is *South-West*, which is opposite to it.

Again, in Geography, we thereby distinguish and relate the Situation and Bearing of Places, Countries, or Cities, one from another: Thus, we say, *Bordeaux* in *France* lies *South* of *London*; and *Bagdat* bears *South-East* from *London*.

Lastly; in *Astronomy*, we say, the *Sun*, *Moon*, or *Planets*, rise on such or such a Point; or so many Points from the *East* or *West* toward the *South* or *North*; which Distance from the *East* or

or West Point is called the *Amplitude of their Rising or Setting*. I shall not mention the Use of the Compass at Sea, as yet.—These are the chief Uses that it serves for in common, and are summarily included in the following Verses:

*The Compass-Points by Art have been design'd,
To shew the various Courses of the Wind;
From hence the Seaman, hence the Farmer knows,
If North, South-East, or South-South-West it blows;
Whence they, or Calms, or Tempests, oft presage,
And shew their Skill in Heav'n's prophetic Page.
Their Use in Geography doth hence appear,
They shew from us how all the Countries bear;
Of Towns from Towns the varied Site we learn,
And Trav'lers hence the dubious Way discern.
From hence, in Astronomic Phrase, we say,
On such a Point Sol ushers in the Day;
Or sets Alderbaran; or Cynthia bright,
Drive West by South the Chariot of the Night.*

Euphras. Well, I never knew so much of the *Compass*, and its Use, before; but I see now it is very considerable: If there remain any other Uses of the *Horizon*, or *Compass*, which we have not enquired into, pray, let me know them, *Cleonicus*.

Cleon. What remains will be better explained when we come to *Globes*; at present we will proceed to the *General Meridian*, and consider its Properties.

DIALOGUE III.

Of the GENERAL MERIDIAN, and the Degrees of Latitude.

Euphrosyne.

I Observe the Names of these Circles import something of their Nature and Use; pray, what is implied by the Name of this Circle, the *Meridian*? *Cleon.*

Cleon. It is derived of the *Latin* Word *Meridies*, which signifies *Mid-day*, or *Noon*; because, when the Sun comes upon the Meridian of any Place, it is then Noon, or Mid-day, at that Place.

Euphros. Very good; but why do you call it the *General Meridian*?

Cleon. To distinguish it from *particular* Meridians: Now you must know, that a *particular*, or *special* Meridian is an imaginary Circle in the Heavens, which passes through the Poles of the World, and the Zenith Point of every Person wheresoever situated on the Earth's Surface: Consequently, there will be as many such Meridians as you can imagine Points from *East* to *West*, all round the Earth; for those which lie *North* and *South* of each other, have the same Meridian; because these Circles lie North and South themselves. Now, in Spheres and Globes, this general Meridian suffices for all the Rest; for since it is fixed, and the Sphere or Globe is moveable about its Axis, you may by turning the same bring any different Part of their Surface under this Meridian, which will then represent the Meridian of that Part or Place.

Euphros. So the Office of this Meridian, I perceive, is vicarious, viz. to represent all, or any of the Rest. Well, since you have let me into the Reason and Significancy of the Nature or Title, let me next know what these Divisions or Degrees are upon it, and to what Use they serve.

Cleon. I will: You observe they begin at the Equinoctial, and proceed each Way to the North and South Pole of the World, to the Number of 90.

Euphros. I do; and pray what do you call them?

Cleon. They are called the Degrees of *Latitude*; by the Word Latitude you are to understand any *Distance*, *North* or *South* of the Equinoctial, towards the Poles; and because such a Distance of any Part of the Sphere or Place on the Globes is estimated by these Degrees, you will readily see the Reason of their Name.

Euphros. I do very plainly; but why are those Degrees numbered a contrary Way on the other Half of the Meridian, or that under the Horizon? For they are reckoned from the Poles towards the Equinoctial there, I see.

Cleon,

Cleon. That's well observed, *Euphrosyne*; the Divisions are there numbered a contrary Way, the Design of which is, that the *Height, or Elevation of the Pole* above the *Horizon* may be readily seen, in any Position of the Sphere; and this *Elevation of the Pole* is always equal to the *Latitude of any Place* on the Earth's Surface.

Euphros. I presume you mean, that so many Degrees as any Place lies North or South from the *Equinoctial*, just so many Degrees will the North or South Pole appear above the *Horizon* of that Place. But how shall I be able to conceive the Truth of this?

Cleon. Very easily, if you consider, that from the *Equinoctial* (Q) to the Pole (N) are just 90 Degrees; also from the given Place (Z) to the *Horizon* (R) are just 90 Degrees; but the Part between the Place and the Pole (ZN) is included in both those equal Parts, and therefore, if it be subducted from both, the Remainders will be equal; that is, the Arch (QZ) will be equal to the Arch (NR) or the *Latitude* (QZ) of the Place (Z) is equal to the *Height, or Elevation* (NR) of the Pole (N).

Euphros. I believe I apprehend the Meaning; but, pray, *Cleonicus*, what would you infer from thence?

Cleon. A very important Use is made of this in divers practical Arts: Thus the *Geographer* and *Diallist*, by taking the *Height of the Pole Star* with a good *Quadrant*, know the *Latitude of the Place*; by this Means also, the *Sailor* finds his *Latitude at Sea*; hence likewise we have a speedy Method of rectifying a *Sphere, or Globe*, as we shall farther see by and by.

Euphros. What farther Uses are made of this great Circle?

Cleon. By Means thereof, we also measure the Distances of the *Sun, Planets or Stars* from the *Equinoctial*, North or South; and the Degrees, or Distance of this Sort, are called the *Declination of those Bodies from the Equinoctial*. — Thus suppose the highest or most Northern Part of the *Ecliptic* be brought to the *Meridian*,—you see it cut the same in $23\frac{1}{2}$ Degrees; and so much is the *Declination of that Point*:—Which you see is the same also on the South Side. The *Declination* also of the *Polar Circle* you observe is $66\frac{1}{2}$ on each Side the *Equinoctial*.

Euphros. I do so; and have now gotten a pretty good Notion of *Latitude and Declination*. But, pray, what is the Use of this

this thin, long Slip of Brass, which I saw you at first take off from the Meridian?

Cleon. It is called the *Quadrant of Altitude*; because it is just a Quarter of a Circle, and divided into 90 Degrees; and being fixed on the highest, or vertical Point of the Meridian (Z) reaches to the Horizon all around; and being moveable on a Pin at the Meridian, it may be carried to any Part on the Sphere or Globe; and so will shew the Height or Altitude of the Sun, or any Star above the Horizon, at any Time, or in any Position of the Sphere. Also being laid over any Place, it shews how that Place bears from you by the Points of the Compass on the Horizon. Also, by this you will be taught how to measure, in Degrees, the Distance of any two Places on the terrestrial Globe, or of any two Stars in the celestial. The graduated Edge of this Quadrant represents on the Globe those imaginary Circles, which the Astronomers call *Azimuths*, or *Circles of Altitude*, and is a Kind of general *Azimuth*, as this, a general *Meridian*. But, enough of this Circle, till we come to the practical Part on the Globes; and shall leave it with the poetical Description, which *Manilius* has given of it, as follows:

This from the Bear
Describ'd, surrounds the Middle of the Sphere;
Divides the Day, and marks exactly Noon,
Betwixt the rising and the setting Sun:
The Signs it changes as we move below,
Run East or West, it varies as you go;
For 'tis that Line, which Way soe'er we tread,
That cuts the Heav'n exactly o'er our Head,
And marks the Vertex; which doth plainly prove,
That it must change as often as we move.
Not one Meridian can the World suffice,
It passes thro' each Portion of the Skies;
Thus, when the Sun is dawning o'er the East,
'Tis their sixth Hour, and sets their sixth at West;
Tho' those two Hours we count our Day's Extremes,
Which feebly warm us with their distant Beams.

DIALOGUE, IV.

*Of the EQUINOCTIAL, and the DEGREES of
LONGITUDE.**Euphrosyne.*

THE next Circle then, *Cleonicus*, which you are to instruct me in the Knowledge of, is the *Equinoctial*: I shall here, as before, desire to be informed of the Reason of the Name.

Cleon. To understand this well, you must remember, as I told you, that this great Circle surrounds the Sphere, exactly in the Middle, or at equal Distance from the Poles of the World; and, secondly, you must observe, that the *Ecliptic*, which represents the Sun's Way, cuts this Circle in two opposite Points, and therefore of Course, the Sun is twice in the Year upon this Circle; and since one Half of this Circle is always above the Horizon, and the other Half below it, it comes to pass, that, when the Sun is in those two Points, the *Days and Nights will then be equal*, which is implied by the Name *Equinoctial*. For the same Reason also, those two Points are called the *Equinoxes*, or *Equinoctial Points*.

Euphros. Very good: Pray, has this Circle any other Name?

Cleon. Yes; upon this Sphere, and the celestial Globe, it is called the *Equinoctial*; but on the terrestrial Globe, it is called the *Equator*; because it *equates*, or divides the Globe of the Earth into *two equal Parts*, or *Hemispheres*, as I said: It is also called the *Equator* in all *Maps*, and *Sea-Charts*.

Euphros. I am glad I know that; for I would not (though a Woman) speak improperly in naming this, or any other Part of the Sphere, or Globes. But what is the proper Use of this Circle?

Cleon. It is, you see, divided into 360 Degrees, beginning and ending in the *Equinox Point*, and numbered from West to East at every tenth Degree. These Degrees are called the *Longitude*, on the terrestrial Globe; and on the celestial Globe and Sphere, they are called *Degrees of Right Ascension*.

Euphros.

Euphros. I have heard much Talk of the *Longitude*, and have as little Knowledge of it, after all, as though I had never heard it mentioned: But as we are now come to the Circle of Longitude, I presume you can give me a better Idea of that Matter.

Cleon. The *Longitude* of a Place is the Distance thereof, reckoned in Degrees of the *Equator*, from that Point of the Equator where the Degrees begin; and the Meridian, which passes through this Beginning of Longitude, is called by the Geographers, the *first Meridian*. Now, suppose the first Meridian be that of the City of *London*, as it is upon the best Globes, then the Arch of the Equator, contained between this and the Meridian of any other Place, is said to be the *Longitude* of that Place from *London*; which you will learn with Ease to find, when we come to the Problems of the Globe.

Euphros. Then I understand, that as the Latitude of a Place is its Distance, *North* or *South* of the Equator, reckoned on the general Meridian; so the *Longitude* of any Place is its Distance, *East* or *West*, from the first Meridian, reckoned on the Equator.

Cleon. You apprehend it very well, *Euphrosyne*; it is so; and the same Thing which on the terrestrial Globe and Maps is called Longitude, is, on the celestial Globe and Sphere, called *Right Ascension*; for with respect to the *Sun*, *Planets*, and *Stars*, their Distance Eastward is also counted on the Equinoctial, from a first, or fixed Meridian, and it is that passes through the Equinox (Q) where the Graduation begins; so that the Meridian, passing through the Sun or any Star, shews on the Equinoctial the Degrees of its *Right Ascension*, or Distance from the Equinoctial Point: But with respect to the Ecliptic, their Distance is called *Longitude*, and is reckoned from a very large, bright Star in the Constellation, *Aries*, which Star I shall shew you hereafter, both on the Globe, and in the Heavens.

Euphros. But why is their Longitude reckoned from that Star, and not from the Beginning of the Ecliptic, as their *Right Ascension* is?

Cleon. Because this Star was formerly near the Meridian of that Point, yea, almost in the Equinox itself, at the Time of *Hipparchus*, about 2000 Years ago; since when, it has moved

forward (with the slow Motion of the Stars I formerly mentioned to you) about $29\frac{1}{2}$ Degrees; or else the Equinoxes have moved so much backward; and this Motion of the Equinoxes backward, makes the Sun enter those Points sooner every Year by nearly 20 Minutes, and this makes what you will find in Books of Astronomy is called the *Precession of the Equinoxes*.

Euphros. Well, I think I understand now what you call the *Longitude*, and *Right Ascension*, of the Planets and Stars: Pray, to what other Purpose does this Circle serve?

Cleon. I have already told you, that the Distance of the Sun, Planet, or Star, from the Equinoctial, North or South, is called its *Declination*: Besides, the Degrees of the Equinoctial are convertible into Time, and shew in what Time any Part of a Revolution of the Sphere, or Globe, is performed.

Euphros. This, I suppose, is done by means of the Hour-Circle, and Hand, which is fixed about the North Pole.

Cleon. You judge right; for that Circle being fixed about the Axis, and the Hand, or Index, upon the Axis, and the Axis itself being fixed to the Circle at each Pole, it must follow, that, if the Sphere be moved, or revolved round its Axis, the Axis will also be revolved, and so carry the Index round upon the Hours engraved on the Circle.

Euphros. I observe, that on the Circle the 12 Hours are twice engraved; pray, why is that?

Cleon. The first 12 Hours shew the Time from Noon till Midnight; the last from Midnight to Noon the next Day; for you must know the *Astronomers begin the Day at Noon*; therefore the two Hours of XII. stand exactly upon the graduated Edge of the general Meridian.

Euphros. Well, now, *Cleonicus*, tell me how you find the Time in which any Motion is perform'd.

Cleon. I will; and first, you observe, I bring the Beginning of the Degrees, or Equinoctial Point, to the Meridian. Secondly, I then (holding the Sphere in that Position) turn the Index about to the Hour of XII. upon the Edge of the Meridian next to us. Thirdly, then you observe, I turn the Sphere once round, till the said Point comes again to the Meridian, and the Index passes once round the Hour-Circle, which shews, that

that one Revolution of the Sphere is performed in twenty-four Hours Time.

Euphros. That is extremely easy to understand; and how then?

Cleon. If one Revolution, or 360 Degrees, be made in 24 Hours, then half a Revolution, or 180 Degrees, is made in 12 Hours; a Quarter, or 90 Degrees, in six; and in that Proportion 15 Degrees of the Equinoctial passes the Meridian in one Hour; and 15 Minutes, or one-fourth of a Degree, in one Minute of Time; which Notions of Motion and Time it will be necessary for you to have a clear Idea of, inasmuch as they are the Grounds of many Problems on the Globes, which you will think very curious and diverting.

Euphros. I am obliged to you thus to prepare me with such previous Knowledge for a right understanding of the Globes, towards which my Inclinations are very strong.

Cleon. We'll make the Introduction to them as short as can be; and to that End we shall dwell no longer on the Equinoctial here; which Circle, *Manilius* thus describes.

*The Equinoctial in the Midst divides
The Sphere, and sees the Pole on both its Sides.
And there, when Phœbus drives, he spreads his Light
On all alike, and equals Day and Night:
For in the Midst he does the Heav'ns divide,
And cheers the Spring, and warms the Autumn's Pride.
And this large Circle drawn from Cancer's Flame,
Twice twelve Degrees divides the starry Frame.*

Creech's Man. Lib. I.

DIALOGUE

DIALOGUE V.

Of the ECLIPTIC, and the Longitude of the Heavenly Bodies.

Cleonicus.

WE are now come to the great Circle, called the *Ecliptic*; because (as I formerly told you) all the Eclipses happen in, or very near it; for this great Circle represents the Sun's apparent annual Path, or Tract, through the Heavens; and therefore, whenever the Moon obscures the Sun, or is eclipsed by him, it must be when she is in, or near this Line.

Euphros. This I understand; as also I remember you told me, this Circle was divided into 12 Parts, or Signs, whose Names and Characters you explained, and are such as I see here engraved: But, pray, what was the Reason of such a Division of the Ecliptic?

Cleon. For the greater Ease and Readiness of judging of, and expressing the Places of the Sun, Moon, and Planets, at any Time; for we can form a more distinct Idea of this in the Parts of a Sign, than in Parts of the whole Circle; the minute Parts of so grand a Whole, as the Circumference and Expanse of the Heavens, obliged Astronomers to make various Divisions of the celestial Circles, and to range the irregular Distribution of Stars in the Surface of the Skies, into certain and determinate Classes of Constellations, the better to reduce the Science to Order and Method.

Euphros. To be sure Regularity and Method helps our Conception of Things very much. I can better apprehend in what Part of the Heavens the Sun, &c. is, when it is said, he is in such a Degree of such a Sign, than I should otherwise been able to have done. But what other Uses do they make of the Ecliptic?

Cleon. By the Ecliptic they estimate the *Longitude*, *Latitude*, and *Declination* of the heavenly Bodies.

Euphros.

Euphros. How is the *Longitude* of these Bodies reckoned?

Cleon. It is estimated in Signs and Degrees of the *Ecliptic*, beginning from the first Minute of *Aries*, viz. in the Equinoctial Point (Q). Thus, suppose the Sun be now in the fifth Degree of *Leo*, Ω , we say, *his Longitude is four Signs, four Degrees, and Part of another*; for he has already passed the four Signs, *Aries, Taurus, Gemini, and Cancer*, and four Degrees of *Leo*, and is in the fifth.

Euphros. Very good; but the Sun is always in the *Ecliptic*; pray, how do you compute the *Longitude* of Planets and Stars, which are not *in*, but at a Distance from the *Ecliptic* on either Side?

Cleon. In this Case, their *Places are reduced to the Ecliptic*, by means of the Quadrant of Altitude fixed to the Brass Meridian upon the Pole of the *Ecliptic*, which then represents a Circle of Longitude: To do this will be a Problem you will be taught on the celestial Globe.

Euphros. Well, and how do you estimate the Latitude of the heavenly Bodies?

Cleon. Their Latitude is reckoned in an Arch of the Quadrant of Altitude (fixed as aforesaid) contained between the Planet, or Star, and the *Ecliptic*; that is, it is their Distance from the *Ecliptic* on either Side, measured upon a Circle of Longitude, which the Quadrant then represents; for Circles of Longitude are, with respect to the *Ecliptic*, the same as Meridians with respect to the Equinoctial, viz. they pass thro' its Poles, and cut it at right Angles.

Euphros. As for the *Declination* of the Sun, or Stars, you have told it me occasionally so often, that I can't forget it.—Pray, what is the broad Circle you called the *Zodiac*, of which you gave me some Account, when we were considering the Theory of the Earth?

Cleon. That Circle, or rather Zone, is put upon some Spheres, but not upon Globes; it answers no great Purpose upon the Sphere, or Globe, inasmuch as it represents only the Space or Limits to which the Planets stray on each Side the *Ecliptic*, which is about five Degrees; so that the Breadth of this Belt is 10 Degrees, as I then told you; and therefore upon this
broad

broad Circle, which you observe in this Sphere, are engraved the Figures of all the Animals of the 12 Signs; it serves to few other Purposes but for Ornament, and to inhanche the Price of the Machine. The Zodiac and Ecliptic are thus described by *Manilius*,

*Two more oblique, and which in adverse Lines
Surround the Globe, observe: One bears the Signs,
Where Phœbus drives, and guides his fiery Horse,
And varying Luna follows in her Course,
Where Planets err, as Nature leads the Dance,
Keep various Measures, undisturb'd by Chance;
Its highest Arch with Cancer's Beams do glow,
Whilst Caper lies, and freezes in the low:
Twice it divides the Equinoctial Line,
Where fleecy Aries, and where Libra shine.
Three Lines compose it, and th' Ecliptic's found
I th' Midst; and all decline into a Round.
Nor is it hid, nor is it hard to find,
Like others, open only to the Mind;
For like a Belt, with Studs of Stars, the Skies
It girds and graces, and invites the Eyes:
To twelve Degrees its Breadth, to thrice threescore
Its Length extends, and comprehends no more.
Within these Bounds the wand'ring Planets rove,
Make Seasons here, and settle Fate above.*

Creech. Lib. 1.

Euphros. Do not the Astronomers distinguish these Signs into different Sorts, or Orders?

Cleon. Yes, and the Astrologers too. The Astronomers divide them into the *Summer* and *Winter Signs*. The *Summer Signs* are those six which make the upper Half of the Ecliptic, or which lie above the Equinoctial, towards the North, viz. *Aries, Taurus, Gemini, Cancer, Leo, and Virgo*; for while the Sun is in them, it makes our *Summer*. The other six, which make the lower Half of the Ecliptic, are called *Winter Signs* for the same Reason.

Euphros.

Euphros. Pray, how do the Astrologers divide the Signs?

Cleon. They, according to their usual Absurdity and Cant, make them of various Kinds, and ascribe to them wonderful Influences and Virtues. Thus, *Manilius* tells us some are Male, others Female Signs; some Human, others Brute:

*Some Signs bear human Shape, and some express'd
In single Figures, bear the Form of Beast.*

Some Signs are single, others double, as *Gemini* and *Pisces*:

*Those Signs are single; now observe the Pairs;
For double Shapes give double Force to Stars,
And each Companion still in each creates
A Change, and vast Variety of Fates.*

Some Signs are of different Species, as *Capricorn*, and *Sagittarius*:

*Such is the Goat, he twists a scaly Train,
The Centaur such, half Horse, and half a Man.*

Some Signs belong to the Day, others to the Night:

*Yet swift, my Muse, like Lark on tow'ring Wings,
Mounts to the Skies, and as she mounts she sings;
She sees Signs various in her airy Flight,
Some which the Day respect, and some the Night.*

Some Signs govern the Water, others the Land:

*Some Signs, 'tis obvious, do the Sea command,
And others claim Dominion o'er the Land.
Thus wat'ry Pisces, and the Crab retain
Their proper Nature, both, and rule the Main.
The Bull and Ram possess their old Command;
They lead the Herds, and still they love the Land.*

Some they reckoned fruitful, and others barren Signs:

*The Crab is fruitful, and a numerous Brood
 Fierce Scorpio yields, and Pisces fills the Flood;
 The Lion's barren, and no Vowus can gain
 The Maid; Aquarius spends his Youth in vain.
 Ah! too remov'd, too far disjoin'd to prove,
 The fruitful Pleasures of encreasing Love!*

Besides these, there are various other Distinctions made of the Signs, not one Jot less whimsical; as you will find in *Manilius's* second Book of his poetical Astronomy and Astrology. But leaving the Dreams and vain Imaginations of the Ancients, let us proceed to the Circles which remain.

Euphros. With a very good Will, *Cleonicus*; let the little Time we have be spent to the Purpose; I had rather be possessed of a little Sterling Science, than all the Parade of trumpery Nonsense.

DIALOGUE VI.

*Of the COLURES, TROPICS, POLAR-CIRCLES, and
 the POLES of the WORLD.*

Cleonicus.

THE next Circles we are to consider, in the Sphere, are those two called the *Colures*, both which pass through the Poles of the World, and cut the Equinoctial at right Angles.

Euphros. And one of them passes thro' the Equinoctial Points, I observe.

Cleon. It does so; and therefore it is called the *Equinoctial Colure*; the other, which passes thro' the Beginning of *Cancer*, is called the *Solstitial Colure*.

Euphros. Whence hath it that Name?

Cleon. From hence, that when the Sun, in his annual Course, comes near to the Beginning of these Signs on either Side, he seems to move neither Northward nor Southward for some Time,
 but

but as it were to be stationary, which Standing still of the Sun, is in the *Latin* called *Solstitium*, whence these two Points are called the *Solstices*.

Euphros. What Distinction is made of these Solstitial Points?

Cleon. Because the Sun, when it is in the Beginning of *Cancer* makes *Midsummer*, that Point is called the *Summer Solstice*; thus the other Point is called the *Winter Solstice*; because, when the Sun is in it, it is then *Mid-winter*.

Euphros. And have not the other Points, which you call the *Equinoxes*, in which the other *Colure* cuts the *Ecliptic*, some distinct Denomination from the Seasons also?

Cleon. Yes; for when the Sun is in the Beginning of *Aries*, it is then the Middle of the *Spring*, which in *Latin* is called *Ver*, and therefore this Equinox is called the *Vernal Equinox*; and when the Sun is in the other Equinox, it is the Middle of *Autumn*, which therefore is called the *Autumnal Equinox*.

Euphros. Then these two *Colures*, I perceive, are, in a Sort, the Boundaries of the Year.

Cleon. That is their Office; they each of them point out two opposite Seasons by their two opposite Parts upon the *Ecliptic*. And these are the two most notable Meridians of those that are fixed; and the *Solstitial Colure* has this in particular, that it also passes through the Poles of the *Ecliptic*, and therefore cuts it also at right Angles. Of these Circles *Manilius* has given us this general Description.

*From Pole all round to Pole two Lines express'd,
Adversely drawn, which intersect the Rest,
And one another: They surround the Whole,
And crossing, make right Angles at each Pole.
These into four just Parts divide the Sphere,
And mark by Signs the Seasons of the Year.*

After this, he gives us a particular Description of each *Colure*, and of their Course thro' the various Constellations of the Heavens: And first of the *Equinoctial Colure*—

*One drawn from Heav'n's high Top, descends from far,
And cuts the Serpent's Tail, and the dry Bear:*

*The Equinoctial Scales, the Snake's Extremes,
 And next the Southern Centaur's middle Beams;
 Then thwarts the adverse Pole, and next divides
 The mighty Whale, and parts its scaly Sides.
 Bright Aries Point, and splendid Trigon past
 The fair Andromeda below the Waste;
 And next her Mother's Head it cuts, and then
 The Pole, and closeth in itself agen.*

Then of the Solstitial Colure —

*Cross this, and from the Pole doth first appear
 The other, thro' the Fore-feet of the Bear,
 And thro' its Neck; which, when the Sun retires,
 First shines, and spreads black Night, with feeble Fires,
 Then parts the Twins and Crab, the Dog divides,
 And Agro's Heel, that broke the frothy Tides.
 And then the Pole, and other Circle cross,
 To Caper turns, contracted in his Frost:
 The Eagle cuts, and the inverted Lyre,
 Black Draco's Folds —————
 The hinder Paws o' th' Bear, and near the Pole
 Its Tail; and closing there compleats the Whole.
 These Rounds immovable, their Site the same,
 Here Seasons fix, nor vary in the Frame.*

Lib. I.

Thus much, at present, is sufficient concerning the *Colures*; let me now proceed to the *Tropics*.

Euphros. Why are those two Circles called the *Tropics*, *Cleonicus*?

Cleom. To understand the Reason thereof nicely, you must know, (which you will easily observe) that while the Sun is going from *Aries* to *Cancer*, he advances every Day more Northward than before he was, till being come to *Cancer*, he is most northerly that he can be; after which, as he descends to *Libra*, he gets every Day more Southward than before. Now, when he is in the Beginning of *Cancer*, it is, that he changes his Motion,

tion, and turns from going Northward to go Southward: Now this *Turning back* of the Sun was by the *Greeks* called *Trope*; from whence the Parallel passing thro' the Beginning of *Cancer* is called the *Tropic of Cancer*.

Euphros. Very good, I understand you well; and I see also the same Reason, why the other is called the *Tropic of Capricorn*, because there the Sun returns from the southerly Course to his northern one. But, pray, what is represented by these Tropics on the Sphere?

Cleon. These Tropics represent (for any Latitude) the *longest* and *shortest Days in the Year*; for they shew the Part of the diurnal Motion of the Sun for the two Days when he is in the Beginning of *Cancer* and *Capricorn*; where he has the greatest and least *Meridian Altitude*; and consequently, when he is in the first Minute of *Cancer*, all that Part of the Tropic of *Cancer*, which is above the Horizon, represents the Length of that Day; and all that is beneath the Horizon represents the *Night* of that Day; and it is easy to observe, from the Sphere, that that Day is the *longest*, and that Night the *shortest* of all others in the Year. In the same Manner, the two Parts of the Tropic of *Capricorn*, above and below the Horizon, shew the *shortest Day* and *longest Night* in the Year.

Euphros. I believe I apprehend your Meaning tolerably well; but you must make some Grains of Allowance to a Novice in these Studies.—Pray, have these Tropics any other Use?

Cleon. They are the Boundaries between the *Torrid* and *Temperate Zones*, of which more hereafter. The *Tropic of Cancer* is thus poetically described by *Manilius*:

*The Line describ'd thro' Cancer's Claws confines
The utmost Limits of the fatal Signs;
There, when the Sun ascends his greatest Height,
In largest Rounds he whirls the Day and Night;
Pleas'd with his Station, there he seems to stay,
Nor lengthens much, nor much contracts the Day.*

And the *Tropic of Capricorn* thus;

Another

Another, Southward drawn, exactly sets
 The utmost Limits to the Sun's Retreats;
 When hoary Winter calls his Beams away,
 Obliquely warms us with a feeble Ray,
 And whirls, in narrow Rounds, the freezing Day.
 To us his Journey's short, but where he stands,
 With Rays direct he burns the barren Sands.
 To wish'd-for Night he scarce resigns the Day,
 But in vast Heats extends his hated Stay.

Lib. I.

We are now come to the *Polar Circles*, which are the last to be considered on the Sphere.

Euphros. These, I remember, you told me were called the *Arctic* and *Antarctic* Circles; pray, whence do they derive these Names?

Cleon. The *Arctic* Circle, or that about the *North Pole*, is so called from *Arctus*, the Greek Name of the Constellation of the greater *Bear*, which is situated very near it; and the *North Pole* is sometimes called the *Arctic Pole*, because it is the last Star in the Tail of the lesser *Bear*; as I shall shew you hereafter, when we come to discourse of the Constellations. The other is called the *Antarctic* Circle, as being on the opposite Part of the Sphere to this.

Euphros. What is the Use of these Circles?

Cleon. They shew the Latitude on each Side the Equinoctial, where the Sun does not set, or go below the Horizon, when he is at the greatest Distance, North and South, that is, in the Beginning of *Cancer* and *Capricorn*.

Euphros. Indeed! is there such a Thing as all Day, and no Night, in that Latitude?

Cleon. Yes; and the nearer you go from the *Polar Circle* to the Pole, the longer the Sun continues above the Horizon; and precisely under the Pole, the Sun sets not for the Space of six Months, or half a Year, as I shall demonstrate to you on the Globes hereafter; and the other half Year it is all Night; that is, the Sun is not seen from that Pole above the Horizon, which in that Case is the Equator itself.

Euphros.

Euphros. This is very wonderful; I hope I shall understand you better upon the Globes. — But, what other Use do you make of these Circles?

Cleon. They are the Boundaries between the *Temperate* and *Frigid Zones*. These Circles also *Manilius* thus describes:

*One tow'rd the North sustains the shining Bear,
And lies divided from the Polar Star
Twice twelve Degrees, and thirty Minutes less;
Which Space the Tropics from the Line possess.*

The *Antarctic* thus:

*The last, drawn round the southern Pole, confines
Those Bears, and lie, the utmost of the Lines.
Wise Nature constant in her Work is found,
Wide as the Arctic is th' Antarctic Round.*

Euphros. But before we leave this Subject, pray tell me one Thing; why are the Ends of the Axis of the Sphere called the *POLES of the World*?

Cleon. The Word *Pole* is *Greek*, and signifies to turn round about: Now, since these two Points in the Heavens, which are opposite to the Ends of the Axis of the Sphere, are quiescent, and all the other Parts of the Heavens have an apparent Motion about them, therefore they were looked upon as the two great *Cardinal Points*, or *Hinges*, on which the whole Fabric of the World did turn.

Euphros. I think the Description of these Poles in *Virgil* is very fine, when he says,

*Two Poles turn round the Globe, one seen to rise
O'er Scythian Hills, and one in Lybian Skies;
The first sublime in Heav'n, the last is whirl'd
Below the Regions of the nether World;
Around our Poles the spiry Dragon glides,
And, like a wandring Stream, the Bears divides,
The less and greater, who by Fate's Decrees,
Abhors to dive beneath the southern Seas;*

There

*There, as they say, perpetual Night is found,
In Silence brooding on th' unhappy Ground:
Or when Aurora leaves our northern Sphere,
She lights the downward Heav'ns, and rises there;
And when on us she breathes the living Light,
Red Vesper kindles there the Tapers of the Night.*

Dryden's Virgil.

But does he not here ascribe a Motion to the Poles themselves?

Cleon. He does; and by it only means, that when we go North or South, they appear to ascend or descend, above or below the Horizon; at least, this is all the Motion the Poles can possibly have. But more of this when we come to the Use of the Globes.

Thus have we passed through so much of the Doctrine of the Sphere, as is necessary to enable you to have a right Understanding of the Globes and Orrery, which will exemplify and illustrate all those Matters, and make them familiar and easy to your Apprehension.

Euphros. Dear *Cleonicus*, you highly oblige and delight me; I think long e'er those Instruments come in Play: Pray, which are we to have next, the Globes, or Orrery?

Cleon. The Orrery, my *Euphrosyne*; I have provided one for that Purpose, which will afford you a pleasurable Entertainment for the next Leisure-Hours.

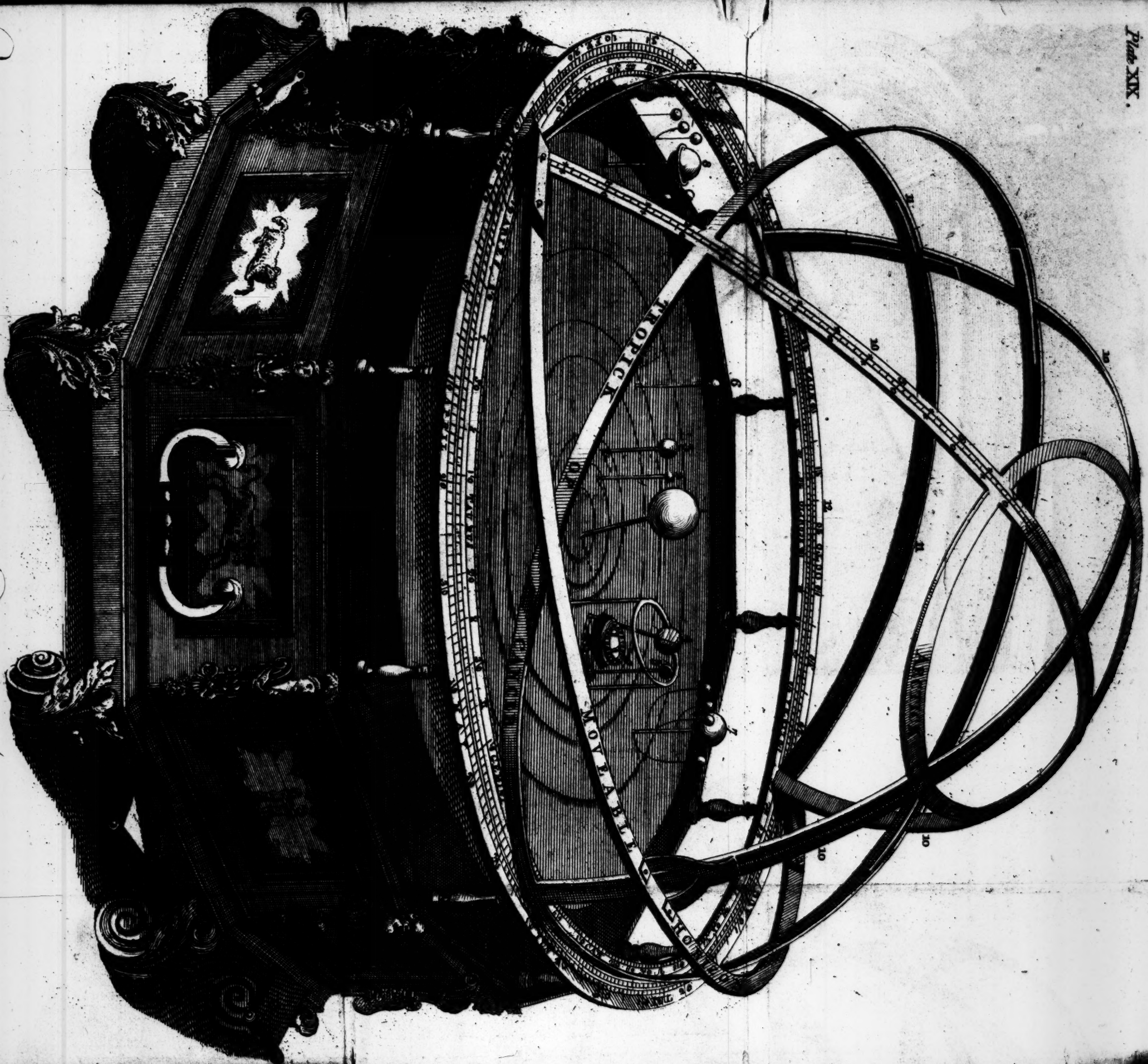
DIALOGUE VII.

Of the ORRERY.

Cleonicus.

YES, my *Euphrosyne*; this is the famed Machine, of which I promised you the Sight and Use, when we last conversed on these Subjects.

Euphrosyne.



The GRAND ORRERY as it was first Made by M. ROWLEY.

Euphros. A glorious Piece of Art it seems to be, indeed! Pray, who was the first Inventor of it?

Cleon. This Machine was invented by Degrees, and made in its utmost Perfection, first by Mr. *Rowley*, for King *George* the First; after which the Earl of *Orrery* bespoke another; and from him, it is supposed by some, that it had its Name: But some will have it derived from a *Greek* Word of the same Sound, which signifies *to see*; because in this Machine *we see all the Motions* of the heavenly Bodies performed in the same Manner as they are in Nature itself.

Euphros. Are there not different Sorts of Instruments of this Kind made; because, I think, I have seen the Cut of an Orrery, of a different Make from this?

Cleon. Yes; since the first Invention they have been variously made, and very much improved by several Artists, particularly Mr. *Rowley*, and Mr. *Wright*; Dr. *Desaguliers* also contrived a curious Machine of this Sort, which he called the *Planetarium*; also there has been made another Instrument, called the *Assimilo*; but the Orrery constructed by the late ingenious Mr. *Dean* exceeds in Point of Neatness and Elegance all that has been yet made, if you except the Motions of the Satellites of *Jupiter* and *Saturn*; but there seems a great Deal wanting yet, to render an Orrery more simple in its Structure, and of an easier Purchase than those which have been hitherto made; for the first were sold for a thousand Guineas; and I have heard of none of the largest Sort for less than three hundred Guineas.

Euphros. Had the ancient Astronomers no Contrivance of this Kind, to represent the Motions of the heavenly Bodies?

Cleon. Yes, it appears they had something analogous to it, made by that famous Mathematician, *Archimedes*, on whom the Latin Poet *Claudian*, wrote a merry Epigram, in the *English* Translation of which you will see *Rowley's* Name, instead of *Archimedes*, as given us by Dr. *Harris* in his *astronomica Dialogue*, Page 182.

*When lately Jove the Orrery survey'd,
He, smiling, thus to Gods in Council said;*

D d

How

How shall we flint presuming Mortals Pow'r?
The Syracusan Sage did, once before,
The heav'nly Motions shew in Spheres of Glass,
And the erratic Orbs and Stars express:
But his Machine, by one fix'd Pow'r and Weight,
Mov'd, and was govern'd, as we are, by Fate;
While the bold Rowley, in his Orrery,
Keeps his first Pow'r, just like his Genius, free:
He knows the secret Spring, and can impart
Laws to the Whole, and to each single Part.
His daring Hand, or brings, or hinders Fate:
He makes the Earth thro' silver Zodiacs run,
Justly obsequious to the golden Sun:
While the bright Moon, shining with borrow'd Light,
Marks out the Months, and rules the sable Night:
And all obedient to his sole Command,
Turn round their Axis, as he turns his Hand;
Their Phases, and their Aspects all display,
And at his Beck exhibit Night or Day.
He makes Eclipses, as he will, appear,
For any past, present, or future Year;
Shews their true Course, and roots out vulgar Fear.
Guiltless Salmoneus at your Suit I flew,
Shall I, to please you, take off Rowley too?
Oh! no, all cry'd, the glorious Artist spare,
Transplant him hither, and make him a Star.

Euphros. This is an ingenious Piece of Wit, indeed; but the Instrument highly deserves it, to all Appearance; it being in the external Frame, and (I doubt not) in the internal Structure, an admirably beautiful and exquisite Piece of Workmanship.

Cleon. All you observe is very right; and Pity it is, that the Costliness and Magnificence of so curious and useful an Instrument should be a Bar to its common Use. I shall now proceed to give you a View of each particular Part, in a general Description of the Whole.

The

The Frame, which contains the Wheel-work, &c. and regulates the whole Machine, is made of fine Ebony, and is near four Feet in Diameter; the Outside thereof is adorned with 12 Pilasters, curiously wrought and gilt: Between these Pilasters the twelve Signs of the Zodiac are neatly painted, with gilded Frames. Above the Frame is a broad Ring, supported with twelve Pillars; this Ring represents the Plane of the Ecliptic, upon which there are two Scales of Degrees, and between these the Names and Characters of the twelve Signs. Near the Outside is a Scale of Months and Days, exactly corresponding to the Sun's Place at Noon, each Day throughout the Year.

Above the Ecliptic stand some of the principal Circles of the Sphere, according to their respective Situations in the Heavens, viz. (No. 10.) are the two Colures, divided into Degrees and half Degrees. No. 11. is one Half the Equinoctial Circle, making an Angle of $23\frac{1}{2}$ Degrees. The Tropic of *Cancer* and the Arctic Circle are each fixed parallel, and at their proper Distance from the Equinoctial. On the Northern Half of the Ecliptic, is a Brass Semi-circle, moveable upon two Points fixed in γ and α : This Semi-circle serves as a moveable Horizon, to be put to any Degree of Latitude upon the North Part of the Meridian. The whole Machine is also so contrived, as to be set to any Latitude, without in the least affecting any of the Inside Motions: For this Purpose, there are two strong Hinges (No. 13.) fixed to the Bottom-Frame, upon which the Instrument moves; and a strong Brass Arch, having Holes at every Degree, through which a strong Pin is to be put, according to the Elevation. This Arch and the two Hinges support the whole Machine, when it is lifted up, according to any Latitude; and the Arch, at other Times, lies conveniently under the Bottom-Frame.

When the Machine is set to any Latitude, (which is easily done by two Men, each taking hold of two Handles, conveniently fixed for that Purpose) set the moveable Horizon to the same Degree upon the Meridian, and you may form an Idea of the respective Altitude, or Depression of the Planets, both Primary and Secondary. The Sun (No. 1.) stands in the Middle

of the whole System upon a Wire, making an Angle with the Plane of the Ecliptic of about 82 Degrees, which is the Inclination of the Sun's Axis, to the Axis of the Ecliptic. Next the Sun is a small Ball (No. 2.) representing *Mercury*: Next to *Mercury* is *Venus*, (No. 3.) represented by a large Ball, and both these stand upon Wires, so that the Balls themselves may be more visibly perceived by the Eye. The Earth is represented (No. 4.) by an Ivory-Ball, all having some of the principal Meridians and Parallels, and a little Sketch of a Map described upon it. The Wire, which supports the Earth, makes an Angle with the Plane of the Ecliptic of $66\frac{1}{2}$ Degrees, which is the Inclination of the Earth's Axis to that of the Ecliptic. Near the Bottom of the Earth's Axis is a Dial-plate, (No. 9.) having an Index pointing to the Hours of the Day as the Earth turns round its Axis.

Round the Earth is a Ring, supported by two small Pillars; which Ring represents the Orbit of the Moon, and the Divisions upon it answer to the Moon's Latitude: The Motion of this Ring represents the Motion of the Moon's Orbit, according to that of the Nodes. Within this Ring is the Moon, (No. 5.) having a black Cap, or Case, which by its Motion represents the Phases of the Moon, according to her Age.—Without the Orbits of the Earth and Moon is *Mars* (No. 6.) The next in Order to *Mars* is *Jupiter*, and his four Moons (No. 7.) Each of these Moons is supported by a crooked Wire, fixed in a Socket, which turns about the Pillar that supports *Jupiter*: These *Satellites* may be turned by the Hand to any Position; and yet, when the Machine is put into Motion, they will all move in their proper Times. The outermost of all is *Saturn*, and his five Moons, (No. 8.) These Moons are supported and contrived after the same Manner with those of *Jupiter*. The whole Machine is put into Motion by turning a small Winch, like the Key of a Clock, (No. 14.) and all the Inside Work is so truly wrought, that it requires but very small Strength to put the whole in Motion.

Euphros. How are these planetary Bodies to be put in Motion? Could I see, or be made sensible of it?

Cleon. Yes: Above the Handle there is a cylindrical Pin, which may be drawn a little out, or pushed in at Pleasure:

When

When it is push'd in, all the Planets, both Primary and Secondary, will move according to their respective Periods, by turning the Handle : When it is drawn out, the Motion of the *Satellites* *Jupiter* and *Saturn* will be stop'd, while all the rest move without Interruption. This is a very good Contrivance to preserve the Instrument from being clogg'd by the swift Motions of the Wheels belonging to the *Satellites* of *Jupiter* and *Saturn*, when the Motion of the rest of the Planets are only considered.

There is also a Brass Lamp, having two Convex Glasses, to be put in the Room of the Sun ; and also a smaller Earth and Moon, made somewhat in Proportion to their Distance from each other, which may be put on at Pleasure.

The Lamp turns round at the same Time with the Earth, and by Means of the Glasses casts a strong Light upon her : And when the smaller Earth and Moon are placed on, it will be easy to shew when either of them will be eclipsed.

Euphros. Well ! I think every Thing admirably adapted to answer the Purpose of such a Machine, and now I presume you are ready to put it in Motion, and gratify my Sight with a View of the Secondary Planets as well as the Primary, in the various Revolutions, which I have not yet seen in any Instrument.

Cleon. I shall do it this Instant :—You see I put on the Handle, and push in the Pin just above it ; and place a black Patch (or Bit of Wafer) upon the Middle of the Sun, right against the first Degree of *Aries* (γ). You may also place Patches upon *Venus*, *Mars*, and *Jupiter*, right against some noted Point in the Ecliptic. If you lay a Thread from the Sun to the first Degree of *Aries* (γ), you may set a Mark where it intersects the Orbit of each Planet ; and that will be a Help to note the Times of their Revolutions.

Euphros. Why am I to place Patches upon *Venus*, *Mars* and *Jupiter*, and not upon *Mercury* and *Saturn* ?

Cleon. Because these Planets are known to have a Motion about their Axis by a constant Observation of the Motion of Spots, seen on their Surfaces, when observed through good Telescopes. These Spots, like those of the Sun, are found to be regular, and to describe such Lines on the Surfaces of the Planets as they really would do, were the Planets to be moved about their Axis, with those Spots on their Surfaces in the Times and

Man-

Manner you here see represented in the Orrery, so that they plainly prove the diurnal Rotation of those Planets. But as for *Mercury* and *Saturn*, the Spots have been observed on their Surfaces sufficient to answer such a Purpose.

Euphros. In what Times do those Planets revolve about their Axis?

Cleon. You will immediately see; for observe, one entire Turn of the Handle answers to the diurnal Motion of the Earth round her Axis, as may be seen by the Motion of the Hour-Index, which is placed at the Foot of the Wire, on which the *Terrella* is fixed. When the Index has moved the Space of Ten Hours, you may observe, that *Jupiter* has made one Revolution compleat round its Axis: The Handle, being turned until the Hour-Index has passed over 23 Hours, will bring the Patch upon *Venus* to its former Situation with respect to the Ecliptic, which shews that *Venus* (♀) has made one entire Revolution round her Axis. *Mars* makes one compleat Revolution round his Axis in 24 Hours, and about 40 Minutes. When the Handle is turned $25\frac{1}{2}$ Times round, the Spot upon the Sun will point to the same Degree of the Ecliptic, as it did when the Instrument was first put in Motion. And, thus by observing the Motion of the Spots upon the Surface of the Sun, and of the Planets in the Heavens, their diurnal Motion was discovered; after the same Manner as we do here observe the Motion of their Representatives, by that of the Marks placed upon them.

Euphros. These Things delight me very much, as they are quite new to me; I observe also, that the Earth moves upon its Axis; but as this is a more important Subject, it will require a particular Consideration, which I shall trouble you with some other Time; at present I shall be glad to attend you on the Subject of the inferior Planets, and their Motion round the Primary; and first, if you please, let me observe the Motion of the Moon about the Earth at the same Time as the Earth keeps moving on in her Orbit about the Sun.

Cleon. This you shall do, and perform it with your own Hands: Take the Winch, and while you turn the Handle you will observe the Planets perform their Motions, in the same relative Times as they really do in the Heavens; then about the Earth you will observe, that the Lunar Orb will depart from a
Point

Point in the Ecliptic about the Earth, and return to the same again in 27 Turns and $\frac{1}{4}$ of the Handle, which is called the *periodical Month*; in Contradistinction to the *synodical Month*.

Euphros. Pray, what is the Difference then between the *periodical and synodical Month*? You have formerly mentioned it to me by Way of Theory, and I should be glad to see it exemplified, as it were, in Fact.

Cleon. I will shew you wherein the Difference consists: I have already observed to you, that the *periodical Month* is the Time, which is taken up by the Moon in departing from any one Point of the Ecliptic, and returning to it the same again; but more particularly thus: I stop the Motion of the Earth, and place the Moon just between the Earth and the Sun; which you know is what we then call the *New Moon*; then, putting the Machine in Motion, you observe, that in 27 and $\frac{1}{4}$ Turns of the Handle, the Moon will make one Revolution, and come to the same Point between the Earth and the Sun again; therefore were the Earth to stand still in the Heavens, the Space of Time between the new Moons would then be 27 and $\frac{1}{4}$ Days, and the *periodical Months* would then be the same. But, as the Case now stands, since the Earth really has a Motion about the Sun, at the same Time that the Moon moves about it, we must represent both in Motion in the Orrery: Therefore, bringing the Moon in the Situation between the Earth and the Sun as before, you will observe, by turning the Winch, that while the Earth moves progressively on, you will make not less than 29 $\frac{1}{2}$ Turns of the Winch, before the Moon will come exactly between the Earth and the Sun again; and this shews the Space of Time in what we usually call the *synodical Month*, viz. two Days and $\frac{1}{4}$ longer than the *periodical Month*.

Euphros. You have made the Thing very clear and easy to be understood; and I fancy I shall be able to read a Lecture on the Orrery myself e'er long: The Moon, you see, always shews the same Face to the Earth in the Orrery as it does in the Heavens; how comes that to pass, *Cleonicus*?

Cleon. For this Reason, that just so much of her Surface as is turned towards the Earth, by her monthly Motion, is turned from it by her Motion round her Axis, which is performed just in the same Time; for, if she had no Motion about her Axis, all

Parts

Parts of the Moon's Surface would be shewn towards the Earth successively in the Course of one Revolution; but of this I shall give you a farther Illustration another Time.

Euphros. I must not expect to know every Thing at once. I shall always be content to wait the Time, you think most proper for my Instruction. — But now for the *Moons of Jupiter*; let me see how they perform their Periods round their Primary.

Cleon. This you will do immediately; but let us place all the *Moons of Jupiter* in one right Line, from their respective Primaries, and then you will observe, by turning the Handle, that they are soon separated and dispersed one from the other, according to their different Celerities: Thus, you see, one Turn of the Handle brings the first Moon about $\frac{4}{7}$ Parts round *Jupiter*, while the Second has described but $\frac{2}{7}$ Parts; the Third about $\frac{1}{7}$, and the Fourth not quite $\frac{1}{8}$ Part, each of its respective Orbits.

Euphros. Yes; and by the Hour-Index I further observe, that the first *Moon* will in 18 and $\frac{1}{8}$ Hours come round to its former Position, or make one Revolution. The Second at the same Time will be almost opposite to the First, and so has made but little more than half a Revolution in the same Time, and the others are in different Aspects according to the Length of their Periods. In short, I have the Pleasure now to see, by telling the Turns of the Handle, and observing the Hour-Index, that the several Planets of *Jupiter* perform their Periods in the same Times that you formerly mentioned. But these *Moons of Jupiter* have been rendered very famous on Account of finding the Longitude by them; now I should be glad to understand the Reason of that Affair. Pray, *Cleonicus*, could I be assisted in that Respect by this Piece of Machinery?

Cleon. Yes, my *Euphrosyne*, you may very easily; by Means of the Eclipses, which these *Moons* suffer in the Shadow of *Jupiter*; and to make the Thing as clear to you as possible, I shall place the Lamp in the Room of the Sun in the Centre to cast a Light on the Body of *Jupiter* and his little System of *Moons*; by this Means, the Shadow of *Jupiter* and his *Moons* will be very evident on a Piece of white Paist-board placed directly behind them from the Sun. And now, by carrying the Candles out of the Room,

Room, *Jupiter* will have no other Lights but what it receives from the Lamp.

Euphros. This is a Sort of Representation of the gloomy Regions thro' which *Jupiter* with his Attendants move; and I plainly perceive, the Shadow of *Jupiter* and of his *Moons* too on the Paistboard; I plainly see the Manner of their apparent Motions; that they move backward and forward in one straight Line, or nearly so: But here they appear very different from what they formerly did thro' the Telescope, where they appeared as so many brilliant Points; here only as dark moving Shadows; and I easily apprehend, by what I see, that when one of those little *Moons* gets into the Shadow of *Jupiter*, it must necessarily disappear to us on that yonder Ball of Earth; and then is said to be eclipsed.

Cleon. This is very true, with respect to their Appearance on the Paistboard; but as for the *Moons* themselves, you have a much better Idea of their Motions now than you could possibly have thro' the Telescope; for here, you see, they move in their proper circular Orbits, as they really do in the Heavens; and here also, you observe, the little white Balls go into, and out of *Jupiter's* Shadow in the same Manner as they do there.

Euphros. This I view with Pleasure, and these Eclipses of the little *Moons*, I observe, are very frequent in those which are next to their Primary, and perform their Periods in the shortest Time. And therefore, I presume, the first of these *Moons* must afford the best Opportunity of finding the Longitude, by Reason of the Frequency of its Eclipses.

Cleon. What you say is very just, there being, generally, two of those Eclipses in three Days; and therefore they afford Mariners and Geographers Opportunities of finding the Longitude almost as often, and as exactly, as they please.

Euphros. But what Method do they take for this Purpose, *Cleonicus*?

Cleon. I will inform you as intelligibly as I can; and in order thereto you must observe the following Particulars.

First, That by reason the Theory of *Jupiter's* Moons is very well ascertained by Observations, the Times in which any of the Eclipses of *Jupiter's* Moons happen can easily be assigned by Astronomers; and accordingly, the Time of the Immersions

and Emerfions of the first *Satellite* are calculated in *White's Ephemeris*, to answer this valuable Purpose. *Secondly*, That the Earth moving about its Axis once in 24 Hours, it is plain, that in one Hour a 24th Part of the Equator will pass under the Meridian of any Place; that is to say, 15 Degrees of Motion under the Equator answers to one Hour of Time, which is 1 Degree in 4 Minutes, or 15 Minutes of a Degree in one Minute of Time. *Thirdly*, The Eclipses of these *Satellites* are seen at the same Instant in every Part of the Earth where the Planet is visible; therefore, *Fourthly*, If two Persons, under the same Meridian, observe such an Eclipse, it must necessarily appear to them at the same Time by a Clock or Watch; but if they live under different Meridians, the Time shewn by their Clocks will be different, when they observe this Phænomenon; and this Difference of Time turned into Motion, by allowing, as I mentioned above, 1 Degree to 4 Minutes, will shew the Difference of the two Meridians in Degrees of the Equator; and this is all that they call *finding the Longitude*.

Euphros. I doubt not but I shall more easily understand these Things, when I have thought about them a little longer; but as I have always found these Ideas much facilitated by Example, I should be glad if you would oblige me in that Respect with an Instance how Longitude is found between any two particular Places; as at *London*, and any other Place.

Gleon. I will, my *Euphrosyne*; see, here is *White's Ephemeris* for the present Year 1757, where all the Immersions of the first *Satellite* are particularly registered from the Beginning of *January* to the 3d of *May*, and after that, the Emerfions out of *Jupiter's* Shadow to *December*, for the several Days, Hours, Minutes, and Seconds, when they happen, as you here observe in their respective Columns.

Euphros. I see them all; and take Notice, that at the End of the Table, he subjoins an Example of its Use, which is the very Thing I want to see explained.

Gleon. That you shall instantly; as thus; suppose you was in some particular Place on the 9th Day of next *October*, and there, with a good reflecting Telescope, you observed the first *Satellite* of *Jupiter* emerging out of the Shadow at 44 Minutes, and 22 Seconds past 10 o'Clock at Night, by a good Watch,
that

that shews Seconds; then you would take the *Ephemeris*, and see what Time the same Phenomenon happened at the Royal Observatory at *Greenwich*, (to which the Numbers in the Table are adapted;) and you will find against *October* the 9th, that it was 48 Minutes, and 42 Seconds after 8 at Night. Now the Difference between the Times of Observation at *Greenwich*, and the Place you are supposed to be in, is 1 Hour, 55 Minutes, and 40 Seconds, which, converted into Degrees and Minutes, in the Equator, will make 28 Degrees, and 5 Minutes, allowing for every Minute of Time 15 Minutes of a Degree as before mentioned.

Euphros. So that these 28 Degrees and 5 Minutes are what you call the Difference of Longitude of those two Places; but Mr. *White* says, this is the Longitude of the Place of Observation to the East of the *British* Observatory: But why does he say to the East, *Cleonicus*? This I do not clearly understand.

Cleon. This you will easily apprehend, my *Euphrosyna*, if you consider, that the Diurnal Motion of the Earth is Eastward, and therefore, at whatever Moment of Time the Eclipse is seen at a Place 15 Degrees Eastward, it must necessarily be one Hour later than the same appears at the Observatory at *Greenwich*; and if the Place were Westward 15 Degrees, then it would happen 1 Hour sooner than at the Observatory; but of this Affair you will be more particularly convinced when we come to the Use of the Globes.

A Table of the Eclipses of *Jupiter's* first Satellite, reduced to apparent Time, 1757.

Immerfions	Immerfions	Immerfions	Emerfions
JANUARY	FEBRUARY	APRIL	JUNE
d. h. m. f.	d. h. m. f.	d. h. m. f.	d. h. m. f.
2 15 13 41	26 11 42 16	22 8 36 28	12 18 31 57
4 9 41 11	28 6 10 53	24 3 5 14	14 13 0 15
6 4 8 43	MARCH	25 21 34 1	16 7 28 33
7 22 36 16		27 16 2 47	18 1 56 50
9 17 3 49	Immerfions	29 10 31 33	19 20 25 8
11 11 31 19		MAY	21 14 53 27
13 5 58 49	2 0 39 31		23 9 21 46
15 0 26 30	3 19 8 10	Immerfions	25 3 50 9
16 18 54 12	5 13 36 53		26 22 18 33
18 13 21 56	7 8 5 37	1 5 0 16	28 16 46 53
20 7 49 41	9 2 34 27	2 23 28 59	30 11 15 13
22 2 17 28	10 21 3 17	Emerfions	JULY
23 20 45 15	12 15 32 7		
25 15 13 9	14 10 0 57	4 20 5 50	Emerfions
27 9 41 4	16 4 29 48	6 14 34 28	
29 4 9 7	17 22 58 39	8 9 3 6	2 5 43 35
30 22 37 11	19 17 27 28	10 3 31 42	4 0 11 57
FEBRUARY	21 11 56 18	11 22 0 19	5 18 40 21
	23 6 25 11	13 16 28 51	7 13 8 46
Immerfions	25 0 54 4	15 10 57 23	9 7 37 13
	26 19 22 58	17 5 26 0	11 2 5 41
1 17 5 14	28 13 51 53	18 23 54 37	12 20 34 17
3 11 33 18	30 8 20 54	20 18 23 4	14 15 2 53
5 6 1 27	APRIL	22 12 51 32	16 9 31 26
7 0 29 37		24 7 19 57	18 4 0 0
8 18 57 51	Immerfions	26 1 48 22	19 22 28 37
10 13 26 6		27 20 16 45	21 16 57 14
12 7 54 23	1 2 49 55	29 14 45 8	23 11 25 56
14 2 22 41	2 21 18 47	31 9 13 29	25 5 54 38
15 20 51 3	4 15 47 39	JUNE	27 0 23 22
17 15 19 26	6 10 16 31		28 18 52 7
19 9 47 59	8 4 45 24	Emerfions	30 13 20 55
21 4 16 33	9 23 14 18		AUGUST
22 22 45 6	11 17 43 12	2 3 41 51	
24 17 13 40	13 12 12 4	3 22 10 18	Emerfions
	15 6 40 56	5 16 38 46	
	17 1 9 53	7 11 7 4	1 7 49 44
	18 19 38 50	9 5 35 23	3 2 18 41
	20 14 7 39	11 0 3 40	4 20 47 38
			6 15 16 36

A Table of the Eclipses of *Jupiter's* first Satellite, reduced to apparent Time, 1757.

Emerfions	Emerfions	Emerfions	Immerfions
AUGUST	SEPTEMBER	OCTOBER	DECEMBER
d. h. m. f.	d. h. m. f.	d. h. m. f.	d. h. m. f.
8 9 45 34	7 12 1 42	5 19 50 26	11 23 41 3
10 4 14 35	9 6 31 1	7 14 19 36	13 18 8 39
11 22 43 37	11 1 0 24	9 8 48 42	15 12 36 15
13 17 12 42	1 19 29 48	11 3 17 48	17 7 3 47
15 11 41 47	14 13 59 8	12 21 46 51	19 1 31 18
17 6 10 51	16 8 28 28	14 16 15 53	20 19 58 51
19 0 39 56	18 2 57 46	16 10 44 51	22 14 26 23
20 19 9 12	19 21 27 4	18 5 13 49	24 8 53 58
22 13 38 28	21 15 56 20	19 23 42 48	26 3 21 33
24 8 7 38	23 10 25 37	21 18 11 46	27 21 49 5
26 2 36 48	25 4 54 54	23 12 40 37	29 16 16 36
27 21 6 3	26 23 24 11	25 7 9 27	31 104 4 5
29 15 35 18	28 17 53 30	27 1 38 11	
31 10 4 34	30 12 22 49	28 20 6 55	
		30 14 35 40	
SEPTEMBER	OCTOBER	Conjunction of the <i>Sun</i> and <i>Jupiter</i> , No- vember 21st	
Emerfions.	Emerfions		
2 4 33 51	2 6 52 3		
3 23 3 7	4 1 21 16		
5 17 32 24			

The Times of the Eclipses in this Table are adapted to the Meridian of the Royal Observatory near *London*, and afford an excellent Method of discovering the Longitude, or Difference of Meridians, between that and any other Place whatsoever, which I shall illustrate by an *Example*.

Suppose on the 9th Day of *October*, the Time of the Emerfion of *Jupiter's* first Satellite, be observed by a Telescope at 44 Min. 22 Sec. past 10 at Night; I find by the Table, that the Time of this Emerfion will happen at the *British* Observatory, the same Night, 48 Min. 42 Sec. past 8: The Difference of the Times is 1 Hour, 55 Min. 40 Sec. which converted into Deg. and Min. of the Equator, will make 28 Deg. 55 Min. the Longitude of the Place of Observation, to the *East* of the *British* Observatory.

Euphros. Well, I suppose by this Time you are tired of talking so much about the Longitude to one of our Sex, who are so seldom employed in putting in Practice any of the great Discoveries of the Philosophers; but as we have naturally a Curiosity of Enquiry into every Thing that we hear of that is of a public or wonderful Nature, we are oftentimes solicitous to be satisfied about Things that do not so immediately concern us. Of this I shall give you a farther Instance by a Query or two concerning *Saturn*, his *Moons*, and *Ring*. I see they move, after the same Manner with those of *Jupiter*, about their Primary; but I observe this System of *Moons* has not the same Position with respect to the Plane of the *Orrery* as those of *Jupiter* have; but as the Time is now far advanced, I shall beg a more particular Account of what relates to *Saturn* and his System the next Opportunity we have for Converse on these Subjects.

D I A L O G U E VIII.

The Use of the Orrery continued.

Cleonicus.

I Remember you took Notice, that *Saturn's Moons* were not alike posited with those of *Jupiter*, in regard to the Ecliptic. And it is true, they are not; for those of *Jupiter* are parallel to that; but those of *Saturn* are inclined thereto in an Angle of about 30 Degrees; as is also the Plane of his Ring.

Euphros. Then, I perceive, that the Shadow of *Saturn's Moons*, cast on the Paistboard behind them, will not appear to move backward and forward in a right Line, like those of *Jupiter*.

Cleon. You rightly observe, they cannot appear so to move to an Eye placed upon the Earth; as you will easily see by the Experiment; for having placed the Paistboard properly behind this Planet, and taken all the Candles but one out of the Room — lay your Hand on the Winch, and put them in Motion, and then you see on the Paistboard, that each respective *Satellite* describes an Orbit of an oval Figure, and what the Geometers properly

properly call an *Elipsis*, one Part of which lies above, and the other below the *Planet*, and its *Ring* in the Center.

Euphros. It greatly delights me to observe these curious Appearances; and now I see, in Fact, how Things are in Nature performed, and brought about: I see the Reason why the *Moons*, while they describe the remote Part of their Orbit, appear direct in Motion, and retrograde, while they describe that Part next to us: — I see likewise, that the Shadow of the *Ring*, in like Manner, is not circular, but elliptical, including the Body of *Saturn*, very much like what formerly appeared in the Heavens thro' the Telescope.

Cleon. It must undoubtedly be pleasant to see the wonderful Machinery of Nature thus represented in Epitome, and yet, at the same Time, so perfectly; but there is one Thing which you have not yet adverted, and that is, that *Saturn* and his whole System, and the Motion about the *Sun*, observe a Paralism of Position; or in other Words, the *Planet*, his *Ring*, and *Satellites*, always respect the same Part of the Heavens in every Part of their Orbits; and this you will easily perceive, if you attend to it but a very short Time; but as this is a curious Phænomenon, I shall represent it to you in the *Orrery*, by Means of the *Lamp* in the Place of the *Sun*, and the *Paistboard*, connected with the Stem of the *Planet*; so as always to be behind it, by which Means the Shadow of the *Ring* will cast a Shadow upon the *Paistboard*, and thereby the several Phases of the *Ring* will plainly appear, as they are observed thro' a Telescope in the Heavens during the several Parts of his long Revolution.

Euphros. This would be a delightful Spectacle, indeed; but, I fear, it will cost you a good deal of Time and Trouble; since the Motion of this *Planet* is so very slow, even in the *Orrery* itself.

Cleon. I shall think no Time or Trouble too much, or ill-spent, to inform the Mind of my dear *Euphrosyne*. Beside that, we need only observe the Phases of the *Ring* thro' one fourth Part of its Period; and seven Years, you know, will soon be over in the *Orrery*; but it will be necessary, in the first Place, to bring this Planet to that Part of its Orbit where the Plane of its *Ring* is most of all open to the View of the

Spectator upon the Earth. This is about the 20th Degree of *Sagittarius*, which Place *Saturn* possessed at the latter End of the Year 1752, to which Place, you see, I now bring the Planet; and the Shadow of the *Ring* on the Paistboard is such, as shews near the whole Body of the *Planet* within it.

Euphros. I see it does, and should have been glad to have had an Opportunity, at that Time, of seeing so fine an Appearance of the *Ring* thro' a Telescope, and the large Space between it and the Body of *Saturn*. I think it is considerably different from what I observed it some Months ago.

Cleon. You will not wonder at that, when you consider, that a few Years make a great Alteration in the Appearance of the elliptic Figure of the *Ring*. For as the *Planet* moves on, at the Rate of about 12 Degrees in a Year, and the *Ring* always keeps parallel to itself, it must be in a Situation, at this Time, much more oblique to the View. — Keep turning the Winch, and you will see the Shadow of the *Ring* becomes more and more elliptical, 'till at length you observe the *Planet* is in the 11th Degree of *Aquarius*, where it is at this very Time, as seen from the Earth.

Euphros. Then here I will stop and view it; and, indeed, I see it much the same as I did through the Telescope, and by this Means am fully convinced how just a Representation this is of Nature. But will not the Pleasure of viewing this *Ring* decrease with its Dimensions?

Cleon. Perhaps not; since Variety always is productive of Pleasure, in some Degree. — For now turn the Winch again, and you will observe, that, when the *Planet* arrives at about 10 Degrees of *Pisces*, the *Ring* seems little more than as a Line that lies over the *Planet*, and at a small Distance on either Side; and thus it will appear in the Beginning of the Year 1759, soon after which, it entirely disappears; and in the Beginning of the Year 1760, it arrives to the Place of the *Nodes* of the *Ring*, which is in about 20 Degrees of *Pisces*, then the *Planet*, passing thro' the Eye of the Spectator, projects the Shadow of the *Ring* into a strait Line, just over the Middle of the Disk of the *Planet*; and if you live to view the Planet at that Time, thro' a Telescope, you will see nothing at all of its *Ring*. From this Situation keep him moving on, and it
will

will be nearly six Months in the *Orrery* before the *Ring* will appear any otherwise than a right Line. But you will observe, that soon after he enters the Sign of *Aries*, the Shadow of the *Ring* will again appear to be curved, which will be in the Year 1761, when the other, or southern Side of the *Ring* will be enlightened by the *Sun*. Thus every successive Year the Phases of the *Ring* will return again 'till seven Years are compleated, when the *Ring* will be again most open to the Telescopic View of the Spectator, which will be in the latter End of the Year 1767, where we may now leave that gloomy Planet; for we can see no more Variety in the remaining half of its Orbit than you have observed in this.

Euphros. I would not give you any unnecessary Trouble, to insist longer on this Phænomenon, as it must necessarily be a Repetition of the same Thing, which I can as easily conceive without seeing it, as with. I shall be extremely desirous often to view this *Planet* with a Telescope; especially, as the Time is now approaching, when the greatest Variety of these Phases will entertain the Eye. But methinks it will be a long Time before I shall have the Pleasure of viewing the *Ring* in its most ample Extent.

Cleon. Why that is the most curious of all the Phases of *Saturn's Ring*, and it may possibly happen, that you may see a fixed Star in the Space between the *Planet* and its *Ring*; for this we are assured of by Mr. *Whiston*, that Dr. *Clarke's* Father once saw a Star in that Situation.†

Euphros. There would be no Reason for me to expect such a Sight, as, I presume, it must be a very rare Appearance, if only one Man has been observed to see it; but, pray, who was the first Discoverer of this wonderful Phænomenon of *Saturn's Ring*, and how many Years is it since?

Cleon. We owe this happy Discovery to the Inventor of the Telescope itself, with which it was seen, the famous *Gallileo*, an *Italian* Mathematician and Philosopher, who first of all viewed it, and published it to the World in the Year 1610, in an ænigmatic *Latin* Sentence, importing, that he had viewed *Saturn* with three Bodies; meaning the Body of *Saturn* it-

F f 2

self

† *Whiston's* Memoirs of Dr. *Clarke's* Life.

self in the Middle, and the oval *Anſæ*, or Ends of *Saturn's Ring*, which appeared, at firſt Sight, like two other Globes,† tho' imperfectly; and, indeed, it was two whole Years before he was convinced that *Saturn* was not a triple Body. However, by frequently viewing of him, he obſerved, with many others, that it was nothing more than a large *Ring*, encompassing the Body.

Euphrof. If this Gentleman was the Inventor of the Telescope, he probably was the firſt too, who muſt have had the great Pleaſure of viewing the *Moons* of this *Planet*.

Cleon. It is natural for you to imagine ſo; but this, however, was not the Caſe; for his Telescope, by which he ſaw the *Ring*, was not ſufficient to ſhew the *Moons*, as it magnified only about 30 Times; but one that will exhibit a View of all *Saturn's Satellites* muſt have a much greater magnifying Power. This happy Spectacle was reſerved to reward the Ingenuity of the celebrated *Hugenius*, who tells us, in his Treatiſe, called *The Celeſtial Worlds diſcovered*, that the 4th of *Saturn's Moons* (which is the largeſt and brighteſt of all) he firſt diſcovered in the Year 1655, with a refracting Telescope, not above 12 Feet long; the other four were diſcovered by the induſtrious *Caffini*, an *Italian Philoſopher*, who had the Opportunity of much longer Telescopes, viz. from 30 to 136 Feet long; the 3d and 5th he diſcovered in the Year 1671, and the two Innermoſt in the Year 1686; at Length, he could view all the Five with a 34 Foot Tube. He gave them the Title of *Sidera Ludoicea*, in Honour of *Louis le Grand*, in Imitation of *Gallileus*, who, ſome Years before, had diſcovered the four *Satellites* of *Jupiter*, and called them by the Name of *Medicea Sidera*, in Compliment to *Medici* II. Great Duke of *Tuſcany*, to whom he addreſſed this Diſcovery, in the Year 1610; but enough of this at preſent; for I intend to put into your Hands very ſoon the before-mentioned Book of *Hugenius*, wherein you will be highly entertained with the moſt ingenious Conjectures concerning the Inhabitants, Plants, and Productions of the *Worlds* in the *Planets*. You have read *Fontinelle's* Plurality of
Worlds

† He advertiſed this Diſcovery in this Sentence, *Altiffimam Plantam tergenimum obſervavi*. In which all the Letters were tranſpoſed, as was the Cuſtom of thoſe Times in ſuch new Diſcoveries.

Worlds in *French*; but you will find this Treatise of *Hugenius* far superior to that, and much better worth your Perusal.

Euphros. That Book, or any other that you shall recommend, I shall be very ready to peruse, as I know you can judge what is calculated for the Improvement of my Understanding. But what is that little Thing I see in your Hand?

Cleon. This is a small Piece of Machinery, which I promised you some Time ago, by which I intend to give you a farther Illustration of that one remarkable Particular in the *Moon*, viz. her shewing always the same Face to the Earth, which we some Time ago touched upon, but abruptly left it, as there was no proper Machinery in the *Orrery* to represent it in so natural a Manner as was necessary to convince you of the true Reason of the Thing; nor must I allow you to ask me any Questions concerning any particular Part of this Appurtenance, which I shall now place upon the *Orrery*. — I take the common Earth and Moon away, and adding this in the room, you see the whole is become new.

Euphros. I observe it with great Pleasure. — When I turn the Winch, I see no annual Motion of the Earth, only the diurnal Motion about its Axis. — I see a little Ball hang by a String, which, I suppose, represents the *Moon*, with that Part of it next the Earth enlightened, and variegated with Spots, and brighter Parts, like what I see in the Face of the full *Moon* itself thro' the Telescope.

Cleon. That pendulous Ball does, indeed, represent the full *Moon*; for you see it is now in Opposition to the *Sun*; but what you are particularly to take Notice of is, that while the *Earth* moves upon its Axis, the *Moon* is moving about the *Earth*, in such a Manner, as always to turn the same Part towards the *Earth*, as you see before the *Moon* did, which we removed from the Orbit; but here it is owing to a very different Cause from that in common *Orreries*, and *Planetariums*. This Effect is there produced by a well-known Piece of Machinery; but here it is owing to the same Cause, as in the Heavens, where you find neither Wheels nor Pullies to produce it.

Euphros. I am at a Loss to guess what this invisible Kind of Cause should be. — I see, that the *Moon* turns constantly the same Face to the *Earth* in her monthly Course. —

I observe, at the same Time, that that visible Part is more or less enlightened, and sometimes wholly dark; but I can see nothing that produces this, unless it be the String by which it is suspended. — How this String should cause it, I cannot conceive, as it is only hung on a brass Stem by a Loop. — I cannot say, but this looks most like Conjunction of any Thing I have seen yet. — How am I to understand it, *Cleonicus*?

Cleon. Very easily, my *Euphrosyne*. There is nothing that will be difficult for you to understand, or that requires any magic Art to account for. Mechanics itself is only the Application of natural Powers to produce the Effects in Miniature, which we see in the World at large; nor does it follow, that, to answer this End, Wheels, Pullies, and other mechanical Contrivances, are always necessary. We may, sometimes, substitute similar Powers in Nature for producing the same Effects. Two Bodies will be actuated alike by the Powers of Gravity and Magnetism. If they are affected by these Powers only, they will always turn the same Parts towards each other. If one of them is fixed, and the other free to move, the latter will always turn the same Part to the former. And this is the Case before us. — For the Earth is placed upon one End of an artificial Magnet, which was covered from your Sight, and in the pendent *Moon*, you will presently see a Piece of a natural Load-stone is included, like a Kernel within a Shell, and the Power of Magnetism in these two Bodies, equally affecting both, causes, that the *Moon*, hanging in a free State, must always turn the same Part toward the central magnetic Body of the *Earth*, just as the *Moon* in the Heavens is made to do the same Thing, by the Power of Gravitation, towards the Globe of our Earth. — You will by this Time understand it. — See, here are both the Magnets.

Euphros. This delights me extremely, *Cleonicus*, and I perfectly comprehend you. — This is down-right Nature, indeed, and sufficiently convinces me how simple the Powers of Nature are, when compared with the complicated Contrivances of the most ingenious Mechanic. — But what are the Consequences, *Cleonicus*, that follow this curious Effect?

Cleon. The first is, that the *Moon* necessarily turns once round her Axis, in the same Time that she moves once round the

the Earth; for by this Means, a Person on the *Moon's* Surface, with his Eye directed constantly to the Earth, must unavoidably view every Point in the Circumference in the *Moon's* Orbit, in the Time of one Revolution; but this he could not do, without being turned once round the Center of the *Moon*, at the same Time. — Do you apprehend me, Sister?

Euphros. I do very clearly; as I cannot but know, that to view every Point of a Circle, in which I am included, I must certainly turn myself once round. — But there is another Thing, I observe, and that is, that those People who are on the other Side of the *Moon* cannot possibly come at a Sight of the Earth at all.

Cleon. It is very true, they cannot, unless they will be at the Trouble of a Journey to that Hemisphere next the Earth; and some of them, for this Purpose, must travel more than 1500 Miles. — Another Thing you will as readily observe, that those who inhabit the middle Part of the Surface of the *Moon*, next the Earth, will see the great Globe of the Earth constantly hanging over their Heads in the *Zenith*, while those, who live in the most Eastern or Western Parts of the said Hemisphere, will see one Half of our Globe in their western and eastern *Horizon*.

Euphros. Well! this is all very strange; but still, I see, that it must be so. — I should be glad to have the Pleasure of such Views of the Earth myself; and were it possible, to get to the *Moon*, and if you could go with me, I should almost be induced to set out.

Cleon. Consider every Thing, my *Euphrosyne*, and you will not be in such a Hurry to leave the Earth. You will find 240,000 Miles a tedious, aerial Journey, and you will find no Castles in the Air, nor Inns of Accommodation on the Road; and which is worst of all, when you come there, it will be necessary for you to have the Art of flying instead of walking, as some of their Mountains are more than nine Miles perpendicular Height, and their Valleys 2 or 300 Miles deep, and as much over; so that, I fear, you would make but a poor Shift there. — Besides, another Thing you have not considered, and that is, that the Days and Nights there are a Fortnight long each, and such tedious Intervals of Light and Darkeness will not agree with
your

your Constitution. You will, therefore, with more Pleasure imagine all these Things, than go thither to enjoy them.

Euphros. Truly, you have cured my Curiosity sufficiently, and I shall be content for the future to stay at my terrestrial Home. However, I cannot help wishing, after all, that it may be some Part of our future Happiness to visit the distant Planets of the System, and even the planetary Worlds of other Systems beyond this. — But enough of this at present; what will be the Subject of our next Speculation?

Cleon. As we are confined to the Globe of our Earth, we shall find many Subjects of Enquiry, and well suited to gratify a rational Mind, relative to the several Phænomena observable in it alone. And it is proper, that we should understand them first, which will be sufficient for the short Space of Time allotted to human Life. Among these, the Seasons of the Year are what I shall next explain to you on the *Orrery*.

DIALOGUE IX.

The Seasons of the Year explained by the Orrery: And First the SPRING.

Euphrosyne.

I Think, *Cleonicus*, when you left me Yesterday, you told me our next Business with the *Orrery* would be to explain the Nature of the SEASONS, and the Manner how they happen by it.

Cleon. I did so, my *Euphrosyne*; and I intend it for the Subject of your Entertainment this Afternoon, if you think fit, and are at Leisure.

Euphros. Very much so; and am impatient of losing one Moment of Time 'till I am made sensible in some Measure of the Reason and Cause of such an agreeable Variety and Succession of *Seasons* which constitute the Year. For tho' no one is more sensible of Heat and Cold, or more affected with the Pleasure and Beauties of the *Spring*, or the heavy and ill-boading

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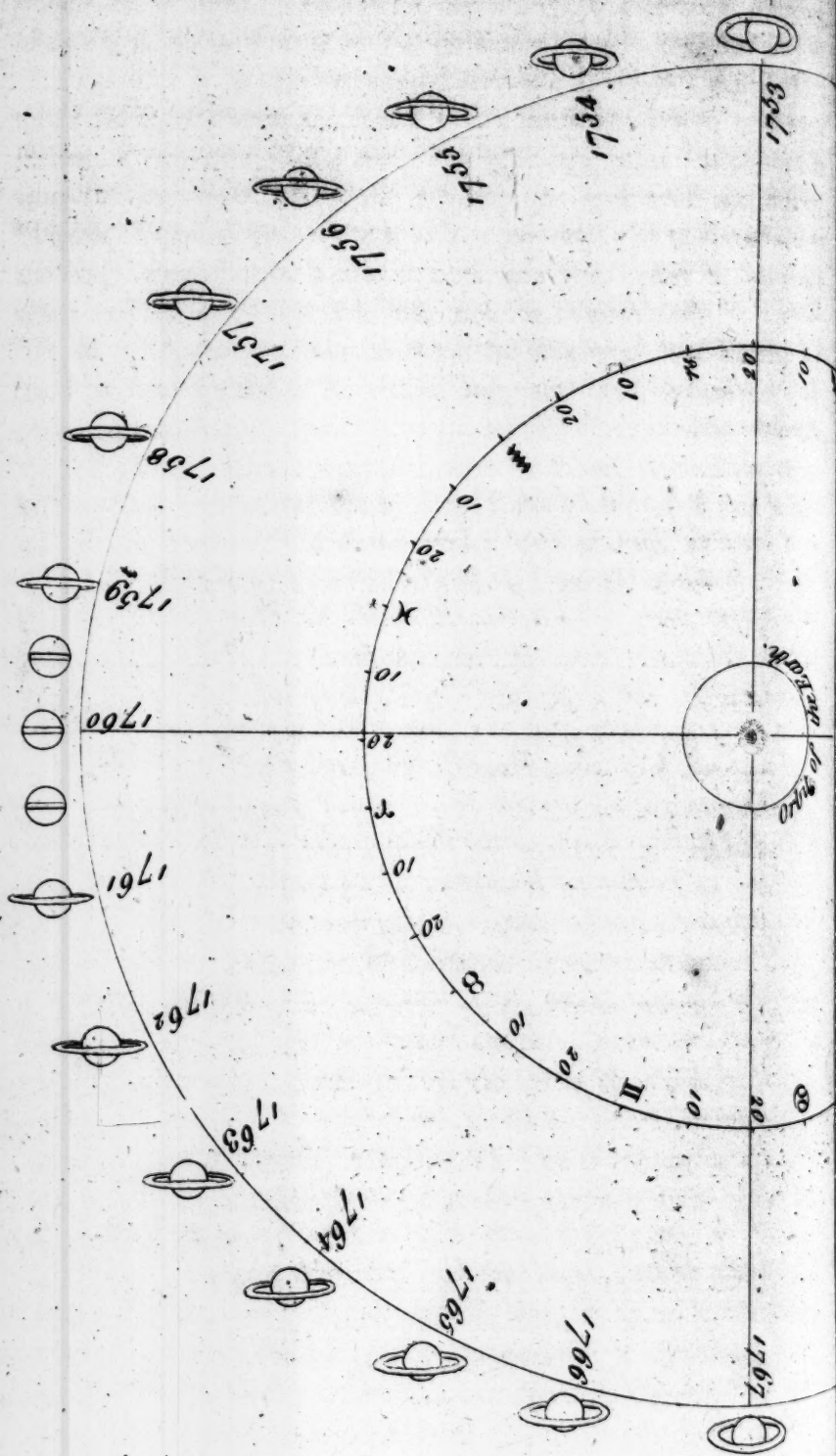
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The PHASES of SATURN'S RING

Plate XX.



boating Aspect of *Autumn*; yet I have never been so rational as to enquire into the Causes thereof, as if I were no more concerned to know them than the Quadrupedes.

Cleon. This ingenuous Reflection on yourself, *Euphrosyne*, is but too just a Satire on the Generality of Mankind, to whom a moderate Pursuit of any Kind of Knowledge, in the Sciences, is thought but too irksome. The Seasons are the most obvious Parts of Nature, nor are they difficult to be understood by Means of the *Orrery*, as you will see. ——— *Ovid* has made a fine poetical Comparifon between the four Seasons of the Year, and the four different States of a Man's Life in these Verses.

Perceiv'st thou not the Procefs of the Year :
How the four Seasons in four Forms appear,
Refembling human Life in every Shape they wear ?
Spring firft, like Infancy, fpoots out her Head,
With milky Juice requiring to be fed ;
Helpless, tho' fresh, and wanting to be led.
The green Stem grows in Stature and in Size,
But only feeds with Hope the Farmer's Eyes.
Then laughs the childifh Year, with Flowrets crown'd,
And lavifhly perfumes the Fields around ;
But no fubftantial Nourifhment receives ;
Infirm the Stalks, unfolid are the Leaves.
Proceeding onward, whence the Year began ;
The Summer grows adult, and ripens into Man.
This Seafon, as in Man, is moft repleat
With kindly Moisture and prolific Heat.
Autumn fucceeds, a fober, tepid Age,
Not froze with fear, nor boiling into Rage :
More than mature, and tending to Decay,
When our brown Locks repine to mix with odious Grey.
Last, Winter fweeps along, with tardy Pace ;
Sour is his Front, and furrow'd is his Face.
His Scalp, if not difhonour'd quite of Hair,
The ragged Fleece is thin ; and thin is worfe than bare.

DRYDEN'S OVID'S MET. L. XV.

Euphros. That is a very beautiful Description of the Seasons, and the Similitude seems very just and natural. — But now for a little Philosophy; pray let me see, by the Orrery, how those different Seasons are brought about in Nature.

Cleon. I will, immediately; but, previous thereto, you must observe, and get a tolerable good Notion of the following Particulars — *First*, That the Motion of the Earth is in the Plane of the *Ecliptic*; that therefore — *Secondly*, the Sun-beams are always perpendicular to that Part of the Earth which lies under the Degree of the *Ecliptic* in which the Sun appears at any Time. — *Thirdly*, That the Axis of the Earth is not perpendicular to the Plane of the *Ecliptic*, but inclined thereto in an Angle of $66^{\circ} \frac{1}{2}$; as I shewed you in the Sphere. — *Fourthly*, That the Axis of the Earth keeps always in a parallel Position, or points always towards the same Parts of the Heavens, throughout its whole annual Course. — *Fifthly*, That the Sun being at so vast a Distance, the Rays which fall on the Earth may be looked upon as parallel among themselves: And, *Sixthly*, That only one Half of a Globe can be enlightened at once by parallel Rays. — Do you think you understand me a-right?

Euphros. I believe I do pretty well, by what you have before taught me; and the Manner in which you now indicate these Things.

Cleon. Well then, since the SPRING is the most delightful and primary Season of the Year, we will begin with it; to represent which, you see, I place the Earth in the Beginning of *Libra* ♎, and then the Sun will appear in the Beginning of *Aries* ♈, which being the *Equinoctial Point*, the Sun must for that Day equally enlighten all Places on the Earth, from Pole to Pole; and to make this Affair as clear to the Eye, as it is in Nature, you see I take this small, wax Taper, and — shutting the Windows all close — I put it into this little brass Case, with a Convex Glass in the Side; that the Light may go to the Earth in parallel Rays — Then I fix it in the Place of the solar Ball, and — turning the Glass directly to the Earth, — you see that Hemisphere of the Earth next the Taper enlightened, — the other being wholly in the dark.

Euphros.

Euphros. I observe it well; and from what you shew'd me on the *Sphere*, I easily conceive, as the Earth revolves about its Axis, the Days, and Nights must now be of equal Duration. — But, pray, when do you put the Earth in Motion, to observe the Particularities of Seasons?

Cleon. Immediately; — you see it begin its Course, proceeding for the Summer Season; — for since, now, every Part of the Earth, equally distant from the Equator, on either Side, enjoys equal Intervals of the Sun's Presence and Absence, the Warmth or Heat of every Clime must now be at a *Medium*, or in a most temperate Degree, and therefore will be productive of all the Vegetation of Plants, and pleasant Temperature of Air, that any Part of the Earth is capable of; which Qualities, I need not tell you, do every where constitute the *SPRING*; which charming Season has afforded a delightful Theme to the Poets, who have variously described it. Of which I shall repeat to you some choice Specimens. The First shall be that of *Virgil*.

*See on the Shore inhabits purple Spring,
Where Nightingales their Love-sick Ditties sing;
See Meads with purling Streams, with Flow'rs the Ground,
The Grottos cool with shady Poplars crown'd,
And creeping Vines on Arbours weav'd around.*

Eclogue IX.

Again:

*When Winter's Rage abates, when chearful Hours
Awake the Spring, and Spring awakes the Flow'rs;
'Tis then the Hills with pleasing Shades are crown'd,
And Sleeps are sweeter on the silken Ground;
With milder Beams the Sun securely shines,
Fat are the Lambs, and luscious are the Wines.*

But his most beautiful, and grand Description of this Season is in the following Lines:

*The SPRING adorns the Woods, renews the Leaves,
The Womb of Earth the genial Seed receives;*

224 *The young GENTLEMAN*

*For then almighty Jove descends and pours,
 Into his buxom Bride, his fruitful Show'rs;
 And mixing his large Limbs with hers, he feeds
 Her Births with timely Juice, and fosters teeming Seeds.
 Then joyous Birds frequent the lonely Grove,
 And Beasts, by Nature stung, renew their Love.
 Then Fields the Blades of bury'd Corn disclose,
 And while the balmy western Spirit blows,
 Earth to the Breath her Bosom dares expose.
 With kindly Moisture then the Plants abound,
 The Grass securely springs above the Ground:
 The tender Twig shoots upwards to the Skies,
 And on the Faith of the new Sun relies.
 The swerving Vines on the tall Elms prevail,
 Unhurt, by southern Show'rs, or northern Hail;
 They spread their Gems, the genial Warmth to share,
 And boldly trust their Buds in open Air.
 In this soft Season (let me dare to sing)
 The World was hatch'd by Heav'n's imperial King
 In prime of all the Year, and Holidays of Spring.
 Then did the new Creation first appear,
 Nor other was the Tenor of the Year;
 When laughing Heav'n did the great Birth attend,
 And eastern Winds their wini'ry Breath suspend.
 Then Sheep first saw the Sun in open Fields,
 And savage Beasts were sent to stock the Wilds;
 And golden Stars flew up to light the Skies,
 And Man's relentless Race from stony Quarries rise.
 Nor could the tender, new Creation bear
 Th' excessive Heat, or Coldness of the Year;
 But chill'd by Winter, or by Summer fir'd,
 The middle Temper of the Spring requir'd:
 When Warmth and Moisture did at once abound,
 And Heav'n's Indulgence brooded on the Ground.*

Georg. II.

Among numberless Descriptions of the Moderns, Mr. Pope has the following most delicate one:

*In that soft Season, when descending Show'rs
Call forth the Greens, and wake the rising Flow'rs;
When op'ning Buds salute the welcome Day,
And Earth relenting, feels the genial Ray.*

And again,

*'Twas now the Season, when the glorious Sun
His heav'nly Progress thro' the Twins had run;
And Jove, exalted, his mild Influence yields,
To glad the Glebe, and paint the flow'ry Fields.*

Mr. Thompson has made this Season the Subject of an exquisite Poem; in which, after a short Invocation or figurative Address in these Words —

*Come, gentle SPRING, ÆTHEREAL MILDNESS, come,
And from the Bosom of yon dropping Cloud,
While Music wakes around, veil'd in a Show'r
Of shadowing Roses, on our Plains descend —*

He inscribes the Poem; and soon after begins the magnificent Description thus —

*At last from Aries rolls the bounteous Sun,
And the bright Bull receives him. Then no more
Th' expansive Atmosphere is cramp'd with Cold,
But full of Life, and vivifying Soul,
Lifts the light Clouds sublime, and spreads them thin,
Fleecy and white o'er all-surrounding Heaven.
Forth fly the tepid Airs; and unconfin'd,
Unbinding Earth the moving Softness strays.
Joyous th' impatient Husbandman perceives
Relenting Nature. —*

And having sung the Praises of the Plough, he considers the delightful Effects of this Season on vegetative Nature.

*Nor thro' the lenient Air alone, this Change
Delicious breaths, the penetrative Sun,
His Force deep-darting to the dark Retreat
Of Vegetation, sets the steaming Pow'r*

At

*At large to wander o'er the verdant Earth,
 In various Hues, but chiefly thee, gay green!
 Thou smiling Nature's universal Robe!
 United Light and Shade! where the Sight dwells
 With growing Strength, and ever-new Delight!
 From the moist Meadow to the brown-brow'd Hill,
 Led by the Breeze, the vivid Verdure runs,
 And swells, and deepens to the cherish'd Eye.*

Having beautifully described the Vegetation and wond'rous Growth of all Kinds of Plants; he next descants on the Influence of the Spring on animated Bodies, and first on the feathered Kind.

*Lend me your Song, ye Nightingales! O pour
 The mazy running Soul of Melody
 Into my varied Verse! while I deduce,
 From the first Note the hollow Cuckoo sings,
 The symphony of Spring, and touch a Theme
 Unknown to Fame, the Passion of the Groves.
 Just as the Spirit of Love is sent abroad,
 Warm thro' the vital Air, and on their Hearts
 Harmonious seizes, the gay Troops begin,
 In gallant Thought, to plume the painted wing;
 And try again the long-forgotten Strain,
 At first, faint warbled, but no sooner grows
 The soft Infusion prevalent and wide,
 Than, all alive, at once their Joy o'erflows
 In Musick unconfin'd. Up springs the Lark,
 Shrill-voic'd, and loud the Messenger of Morn;
 E'er yet the Shadows fly, he mounted sings
 Amid the dawning Clouds, and from their Haunts
 Calls up the tuneful Nations. Every Copse
 Thick-wave, and Tree irregular, and Bush
 Bending with dewy Moisture, o'er the Heads
 Of the coy Choristers that lodge within
 Are prodigal of Harmony.*

It would be tedious to pursue him thro' all his fine Reflections on the vernal Season, and its agreeable and beneficent Effects on all the World. — I fear I have tired your Patience already; but,

but, my dear *Euphrosyne*, I know you'll forgive a Digression of this Kind, were it much longer, in Complaisance to the Muses.

Euphros. I hear you with equal Patience and Pleasure. — This happy Season can't be too much extolled. — But, see, the Earth is moved far on; the Spring begins to give Way to Summer, which I suppose will here succeed, as it does in Nature.

Cleon. In the very same Manner. As the Middle of the Spring Season is about the 20th of *March*, when the Sun (S) appears in the Beginning of *Aries* (♈); so about the Beginning of *May*, the Spring ends, and the Summer Season commences, which we will next contemplate on the *Orrery*.

DIALOGUE X.

Of SUMMER.

Euphrosyne.

THE Earth being near advanced to *Capricorn* (♋) shews the Serenity of Spring is past, and the near Approach of Summer. — But since the Earth is still at the same Distance from the Body of the Sun, I can't rightly conceive how it comes to pass, that the Sun-beams are so much hotter than at other Times.

Cleon. To explain that is one great Design of the *Orrery*. — In order to which, you must consider, and understand, that the principal Characteristics of *Summer* are two, viz. (1.) *The Days are then longest*; and (2.) *The Heat is most intense*. How the Days are now longest, I shall explain to you at large, after we have done with the Seasons. — I shall now only shew you why the Heat is greater *with us* than at any other Time of the Year.

Euphros. Why do you say, *with us*, so emphatically, *Cleonicus*?

Cleon. Because, with respect to the Earth in general, the Sun's Heat is nearly always the same; but greater or lesser only in regard of some particular Place at some certain Seasons
of

of the Year, as with us when the Sun appears in *Cancer* (♋); for at that very Time it is coldest in some other Part of the Earth.

Euphros. But what I want to know is, how it comes to pass, that it is sometimes very hot, and sometimes very cold at different Times of the Year in the same Place?

Cleon. The Reason of that will easily be understood, if you remember what I observed to you about the Axis of the Earth (N S) not being perpendicular to the Plane of the Ecliptic (or) but inclined thereto; and also, that the Earth so moves as always to have its Axis parallel to itself, or pointing to the same Part of the Heavens.

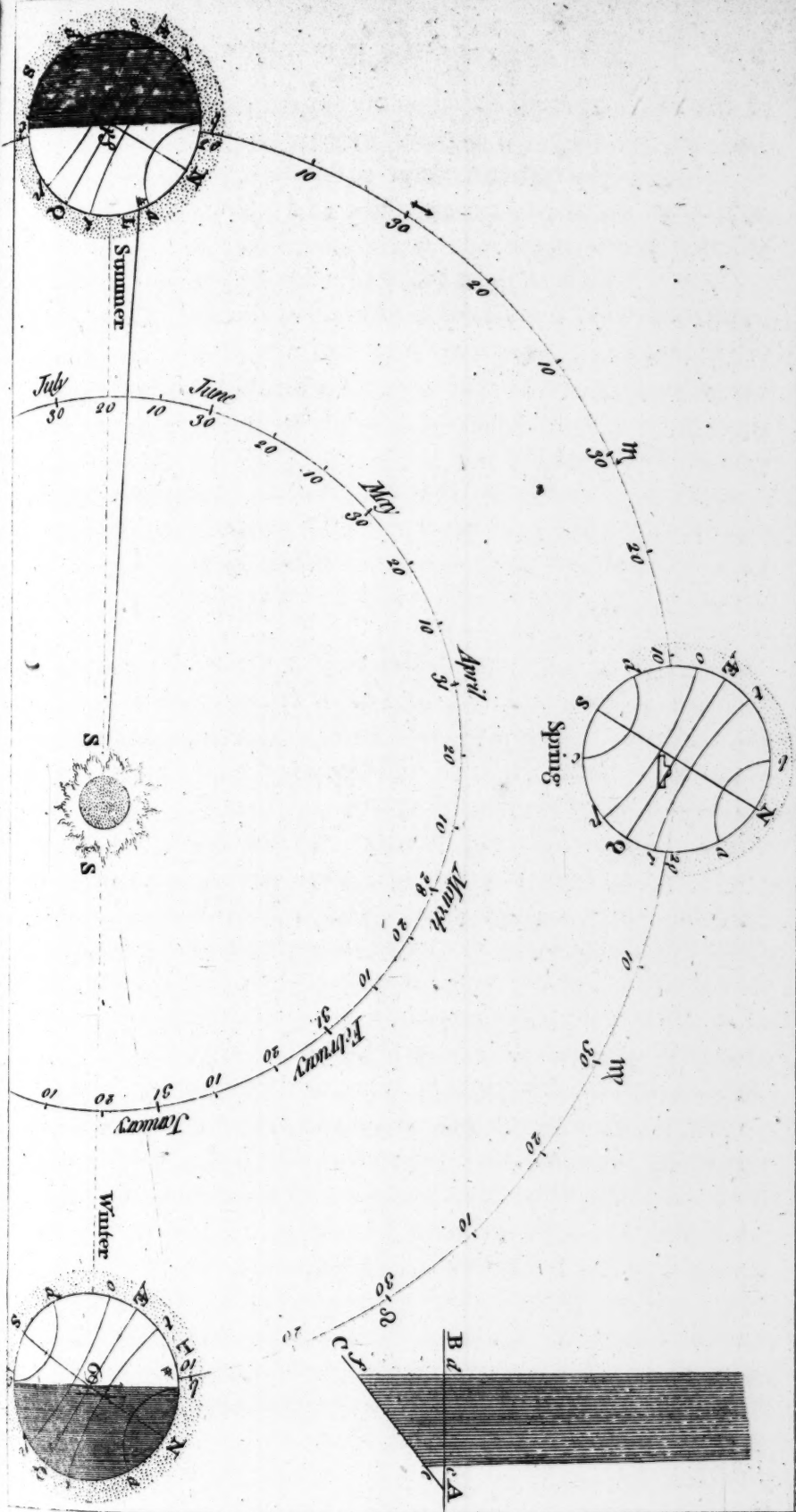
Euphros. I remember that very well, and — now I look on the Earth, I readily see what follows, *viz.* the North Pole (N), by this Inclination of its Axis, is carried more and more towards the Sun, as it arrives nearer and nearer to the Beginning of *Capricorn* (♑). —

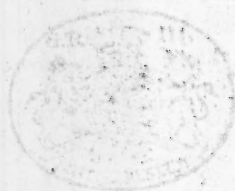
Cleon. Very good, my *Euphrosyne*; and when it comes there, you will observe, that all the Places of the Earth which have North Latitude are turned more directly towards the Sun than when in its first Position in the Spring. And, consequently, the more directly the Sun's Rays fall on any Part, the thicker or denser they will be, and therefore, so much the hotter. Thus, for Example, suppose a Parcel of Rays, *abcd*, fall directly, or perpendicularly on any Plane, A B, and obliquely on another Plane, A C, 'tis evident, they will take up a smaller Space, *cd*, in the former, than *ef*, in the latter; and so their Action, *i. e.* their Heat would be much greater in the lesser Space *cd*, than in the larger *ef*; and if, instead of Lines, we suppose *cd* and *ef* to be the Diameters of Surfaces, then the Heat on those Surfaces will be inversely as the Squares of the Diameter, *viz.* as the Square of *ef* to the Square of *cd*. And this would be the Case with respect to the Inhabitants of the Earth, if we were to regard the Sun's Rays only; but, as I said, the greater Length of Day contributes to augment the Heat: And moreover, another Reason which I have not before mentioned, is, that the Rays do now pass through a far less Portion of the Atmosphere, and therefore, are not so much refracted and weakened by it, as when they fall more obliquely on the Earth, and so pass thro' a greater Part of it.

Euphros.

The SEASONS of the YEAR.

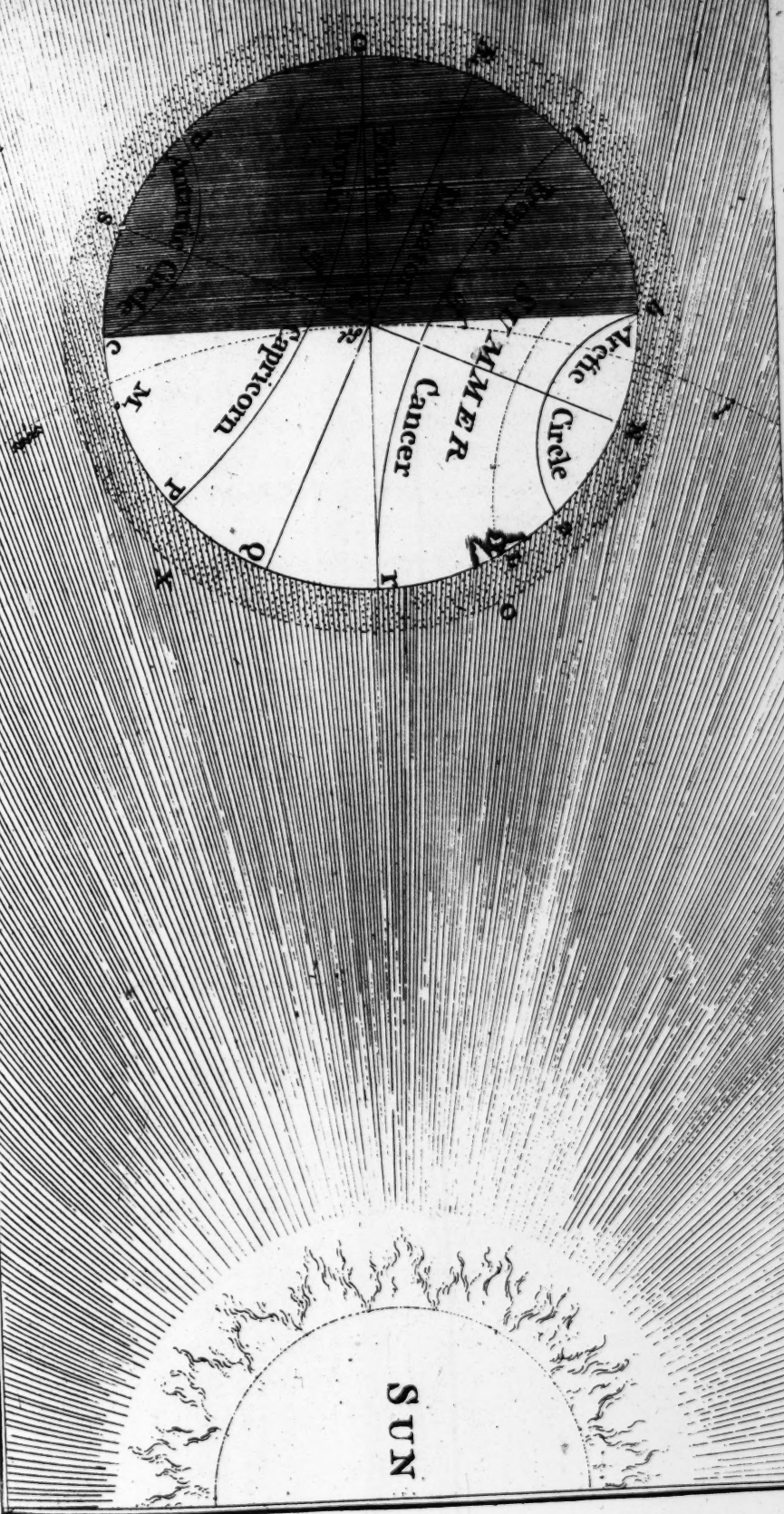
Plate XXI.





THE SUMMER SEASON .

Plate XXII .





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Euphros. When you talk of the Atmosphere, you go a little out of my Depth, *Cleonicus*; pray, explain that a little farther to me.

Cleon. I will. The Earth is surrounded on all Parts by a Body of Air of a spherical Form to a certain Height (which I have represented by the dotted Circumference about the Figure of the Earth in this little Scheme, for Illustration Sake) this Body of Air being filled with watry, &c. Particles, exhaled from the Earth, occasions the Sun's Rays, in passing thro' it, to be variously refracted, and blended thro' its Substance, and the more so, the more obliquely they are received by it; and consequently, the more their Action or Effect is weakened and abated on the Surface of the Earth.

Euphros. Pray give me an Example of this, *Cleonicus*; I shall then better apprehend you.

Cleon. You see the Earth is now just arrived to the first Scruple of *Capricorn* (φ) where it has the same Position, with Regard to the Sun, as the Figure thereof has in this Scheme. At this Time the Days are longest, and the Sun's Rays fall most direct upon us, and therefore are strongest in their immediate Effects, and therefore, this is the *Middle of Summer*, which you see happens about the 11th of *June*; for against that Day the Earth now stands in the *Orrery*.

Euphros. I see it does; and had you not better stop it there for some Time?

Cleon. Yes, I intend it. ——— Observe, in the Scheme, the Situation of the City of *London* L, the Position of the Earth, you see, at this Time turns all the Northern Hemisphere (QNÆ) as much towards the Sun as they can be, and more than at any other Time of the Year; and consequently, the Sun's Rays fall on this Metropolis, at this Time, more directly than at any other; and their Passage thro' the Atmosphere (OL) the shortest of all. And therefore all Things conspire to make this the warmest, and most lightsome Season of the Year with us.

Euphros. You have made the Matter so plain, that I should be dull not to understand it tolerably well. ——— And I further observe, that in this Position of the Earth, all the Southern Hemisphere (QSÆ) is turned as much away from the Sun as

can be; and so, I presume, it must be Winter with all those who live in Southern Latitude, at this present Time. —

Cleon. You judge very right; for suppose the Place M hath its South Latitude QM equal to the North Latitude of London QL; the Days will there be the shortest, the Sun's Rays will fall on it most obliquely, and their Passage thro' the Atmosphere (XM) will then be greatest of all; and consequently, every Thing there combines to make it the coldest Season of the Year; i. e. their *Winter*; all which is, I think, evident from the Scheme.

Euphros. It is so; and I never considered 'till now, that when it is Summer in one Part of the Earth, it is Winter in that which is equally distant from the Equator on the other Side.

Cleon. I am glad to see you apprehend it now; for that is indeed the Case; and thus, I think, you have as compleat an Idea of the Reasons of the Summer-Season, as at present I can give you; tho' I may have Occasion hereafter to say something further on this Head. One Thing yet remains, and that is, to shew you what Parts of the Earth participate of the Sun's Light and Heat, and which are excluded from it, in the present Situation thereof. For it is not now, as in the Spring, when all the Earth received the enlivening Influences of the Sun-beams in the Space of 24 Hours, and had an equal Share of his Absence; but now some Parts enjoy continual Day, while others are overwhelmed in Darkness of equal Duration.

Euphros. This, I suppose, you can shew by the Taper and darkened Room, as before.

Cleon. Yes, my *Euphrosyne*; — I'll shut the Windows — and setting the Candle in the Place of the Sun, that the Light may fall on the Earth — I put the Machine in Motion, — and you see the Parts of the Terrella illuminated, either wholly, or in Part, or not at all, in every diurnal Rotation about its Axis.

Euphros. I do; and it is very curious to behold! — I see all the Parts about the North Pole (N) as far as the Arctic Circle (ab) constantly enlightened during the whole Rotation. — On the contrary, I observe all the Parts about the South Pole, to the Antarctic Circle (cd), are wholly in the dark — while all other Parts of the Earth, the nearer they are to the North

North Pole, or rather the *Artic Circle* (*ab*), the more they share of the Sun's Light, in each Revolution of the Earth.

Cleon. Your Observations are all very just, and take in almost all I intended; ——— but farther, you see, that, as the Earth advances in her annual Orbit from *Capricorn* towards *Aries* (γ), the North Pole (N) recedes from the Sun; and leaves, by Degrees, those Places within the *Artic Circle* (*ab*) remotest from the Polar Point, to share a Part of the Night; and the more largely so, as they are more remote from the Pole N.

Euphros. Yes, all this I see, *Cleonicus*, with infinite Pleasure. ——— And farther observe, that the same Parts about the South Pole (S) which before lay obscured in Night, are in the same Manner restored by Degrees to cherishing Light and Day.

Cleon. I do assure you, my *Euphrosyne*, without a Compliment, such is your Perspicuity, that nothing I know of worthy Notice, has escaped your Eye, in Relation to this Season, and the *Phænomena* thereof, by the Orrery. ——— We will now again throw open the Windows, and restore *Phæbus* to his central Throne, that he may again preside o'er the moving Orbs of the System. ——— The Earth keeps journeying on; ——— she is now got near the Beginning of *Aquarius* (♒) ——— and the *Summer* declines towards *Autumn*.

Euphros. What Time do you suppose the *Summer* to end, and *Autumn* begin?

Cleon. About the Beginning of *August*; when the Sun appears about the *Middle* of *Leo* (♌), and the Earth is in the *Middle* of *Aquarius*, where in a few Minutes you will see her.

Euphros. If the *Summer* expires about *August*, how comes it to pass, that that is, for the most Part, the hottest Month in the Year?

Cleon. You may conceive the Reason of that after this Manner: During the *Summer* Months, the Days, being longer than the Nights, pour more Rays, or Heat upon the Earth, than the Coldness of the Nights can extinguish; and therefore, there will every Day be an Excess of Heat remaining in the Earth; and this being every Day augmented thro' the whole *Summer*, must be very considerable at the latter End; when the Earth will be heated, not only by the Sun-beams falling on it, but also by those which remain in it in great Quantity, the Forces of

both which conjoined, produce those almost insupportable, sultry Heats, which usher in the *Autumn*.

Euphros. What you say, *Cleonicus*, seems very consonant to Reason; and now I have a much more extensive and rational Idea of this Season, and its various Qualities than I had before. — 'Tis true, the Summer Heat is so excessive, as makes it, in Point of Pleasure, yield to the Spring. —

Cleon. Yes it does so; but even those intense Heats, which to us are irksome and almost unsufferable, are in Nature as beneficial and necessary as the Temperament of any other Season: For hereby all the Flowers, Fruits, and Seeds of Trees and Plants, in every Clime, are brought to Maturity and Perfection.

— But the special Advantages of this, as well as the other Seasons, are most beautifully described by the Poets. —

Thus Sir *Richard Blackmore*:

*The Heats of Summer Benefits produce,
Of equal Number and of equal Use.
The sprouting Births and beauteous vernal Bloom,
By warmer Rays to ripe Perfection come;
Th' austere and pond'rous Juices they sublime,
Make them ascend the porous Soil, and climb
The Orange Tree, the Citron, and the Lime:
Which, drank in Plenty by the thirsty Root,
Break forth in painted Flowers and golden Fruit.
They explicate the Leaves, and ripen Food
For the Silk-labourers of the Mulb'ry Wood:
And the sweet Liquor on the Cane bestow,
From which prepar'd the luscious Sugars flow:
With gen'rous Juice enrich the spreading Vine,
And in the Grape digest the sprightly Wine.
The fragrant Trees, which grow by Indian Floods,
And in Arabia's aromatic Woods,
Owe all their Spices to the Summer's Heat,
Their gummy Tears, and odorif'rous Sweat.
Now the bright Sun compacts the precious Stone,
Imparting radiant Lustre, like his own:
He tinctures Rubies with their rosy Hue,
And on the Sapphire spreads a heav'nly blue;*

For

*For the proud Monarch's dazzling Crown prepares
Rich, orient Pearl, and adamantine Stars.*

Creation, Lib. II.

And Mr. Thompson, in his admirable Poem:

*When the bright Virgin gives the beauteous Days,
And Libra weighs in equal Scales the Year;
From Heav'n's high Cope, the fierce Effulgence shook,
Of parting Summer, a serener Blue,
With golden Light irradiate, wide invests
The happy World. Attemper'd Suns arise,
Sweet-beam'd, and shedding oft thro' lucid Clouds
A pleasing Calm; while broad, and brown, below,
Unbounded Harvests hang the heavy Head.
Rich, silent, deep, they stand; for not a Gale
Rolls its light Billows o'er the bending Plain;
A Calm of Plenty! 'till the ruffled Air
Falls from its Poize, and gives the Breeze to blow.
Rent is the fleecy Mantle of the Sky;
The Clouds fly different; and the sudden Sun,
By Fits effulgent, gilds th' illumin'd Field,
And black by Fits the Shadows sweep along.
A gayly checker'd, wide extended View,
Far as the circling Eye can shoot around,
Convolv'd, and tossing in a Flood of Corn.*

DIALOGUE XI.

Of AUTUMN.

Euphros.

I Think we have had a very pleasing Speculation on the two first Seasons, *Spring* and *Summer*; and they succeed so fast in this Machine, that *Autumn* is already very far advanced upon us, the Earth being some Degrees in *Pisces* (♊). —

Cleon.

Cleon. Yes, the Days now grow shorter, and the Nights lengthen; the Parts towards the North Pole, and within the Arctic Circle, are now carried farther and farther from the Sun, as those, towards and about the South Pole, are turned more and more to its Beams. And thus, with the former, the Summer-Heats, as with the latter, the Winter-Colds abate, and Nature is again restored to an *Equilibrium*, or a due and equal Distribution of Light, and Heat; Day and Night, to all Parts of the Earth equally distant from the *Equator*, on each Side. And this obtains, when the Earth enters *Aries* (γ), or the Sun is seen in *Libra* (Δ).

Euphros. Tho' there be an Equality of Days and Nights, &c. in *Autumn*, as in the *Spring*; yet it is not near so pleasant a Season. The Trees and Fields are then green and blooming; now brown and fading. Nature seems now sickening, and drawing towards its Dissolution; but then revived and regenerated in its various Produce. Yet I can't say, but *Autumn* has its Pleasures too; the Harvest-Fields of ripened Grain, the Labourers performing their several Tasks therein, the *autumnal* Seasons of Ploughing and Sowing, and various other Things, make rural Scenes delightful at this Season. — I am greatly delighted with *Homer's* beautiful Description of the HARVEST-FIELD—

*Another Field rose high with waving Grain;
With bended Sickles stand the Reaper-train:
Here stretch'd in Ranks the levell'd Swarths are found,
Sheaves heap'd on Sheaves, here thicken up the Ground.
With sweeping Stroke the Mowers strow the Lands;
The Gath'ers follow, and collect in Bands;
And last, the Children, in whose Arms are borne
(Too short to gripe them) the brown Sheaves of Corn.
The rustic Monarch of the Field descries,
With silent Glee, the Heaps around him rise.
A ready Banquet on the Turf is laid,
Beneath an ample Oak's expanded Shade;
The Victim-ox the sturdy Youth prepare;
The Reaper's due Repast, the Womens Care.*

And

And of the VINTAGE —

*Next, ripe in yellow Gold, a Vineyard shines,
Bent with the pond'rous Harvest of its Vines;
A deeper Dye the dangling Clusters show,
And curl'd on silver Props, in Order glow:
A darker Metal mix'd, intrench'd the Place,
And Pales of glitt'ring Tin th' Enclosure grace.
To this, one Path-way gently-winding leads,
Where march a Train with Baskets on their Heads.
(Fair Maids and blooming Youths) that smiling bear
The purple Product of th' autumnal Year.
To these a Youth awakes the warbling Strings,
Whose tender Lay the Fate of Linus sings;
In measur'd Dance behind him move the Train,
Tune soft the Voice, and answer to the Strain.*

And that of PLOWING seems to be admirably fine. —

*A Field deep furrow'd next the God design'd,
The third Time labour'd by the sweating Hind:
The shining Shares full many Plowmen guide,
And turn their crooked Yokes on either Side,
Still as at either End they wheel around,
The Master meets them with his Goblet crown'd;
The hearty Draught rewards, renews their Toil;
Then back the turning Plough-shares cleave the Soil:
Behind, the rising Earth in Ridges roll'd,
And sable look'd, tho' form'd of molten Gold.*

Pope's Homer, B. XVIII.

Cleon. The Lines you repeat, are the most beautiful Part of Homer's Description of *Rural Life*. — The *autumnal Season* is the chiefest Time of Action abroad. And hence the Poets, since *Homer*, have always made the Labours of the Harvest the chief Theme of their Lays, whenever this Season has been their Subject. — Thus *Sir Richard Blackmore*:

Next

236 *The young GENTLEMAN*

*Next Autumn, when the Sun's withdrawing Ray
The Night enlarges, and contracts the Day,
To crown his Labour to the Farmer yields
The Yellow Treasures of his fruitful Fields;
Ripens the Harvests for the crooked Steel,
(While bending Stalks the rural Weapon feel)
The fragrant Fruit for the nice Palate fits,
And to the Press the swelling Grape submits.*

Creation, B. II.

Virgil, from the various Incidents of this Season, gives many singular and notable Epithets thereto; thus, addressing his 2d *Georgic* to *Bacchus*, he says,

*To thee his Joys the Jolly Autumn owes,
When the fermenting Juice the Vat o'erflows.*

In another Place, on Account of the *Vintage* at this Time of the Year, he calls it the *Vine-leav'd Autumn* ;* and because the Sun now enters *Libra*, or the Balance, he makes *Autumn* weigh the Year.

*Now sing we stormy Stars, when Autumn weighs
The Year, and adds to Nights, and shortens Days;
And Suns declining shine with feeble Rays.*

Geor. B. I. }

Lastly, he calls *Autumn* the *Evening of the Year* ; as if *Spring* and *Summer* were the *Morning* and *Noon*, and *Winter* the *Night* thereof.

———— *The Evening of the Year;*
*When Woods, with Juniper and Chestnuts crown'd,
With falling Fruits and Berries paint the Ground;
And lavish Nature laughs, and strews her Stores around.*

}

Euphras. This Season of the Year, I think, is remarkable upon some other Accounts; for Instance, the *Harvest Moon*, which I have heard much Talk of, but should be glad to know the Reason of it better than I do: Can you explain it, *Cleonicus*?

Cleon.

* *Autumnus pampineus.*

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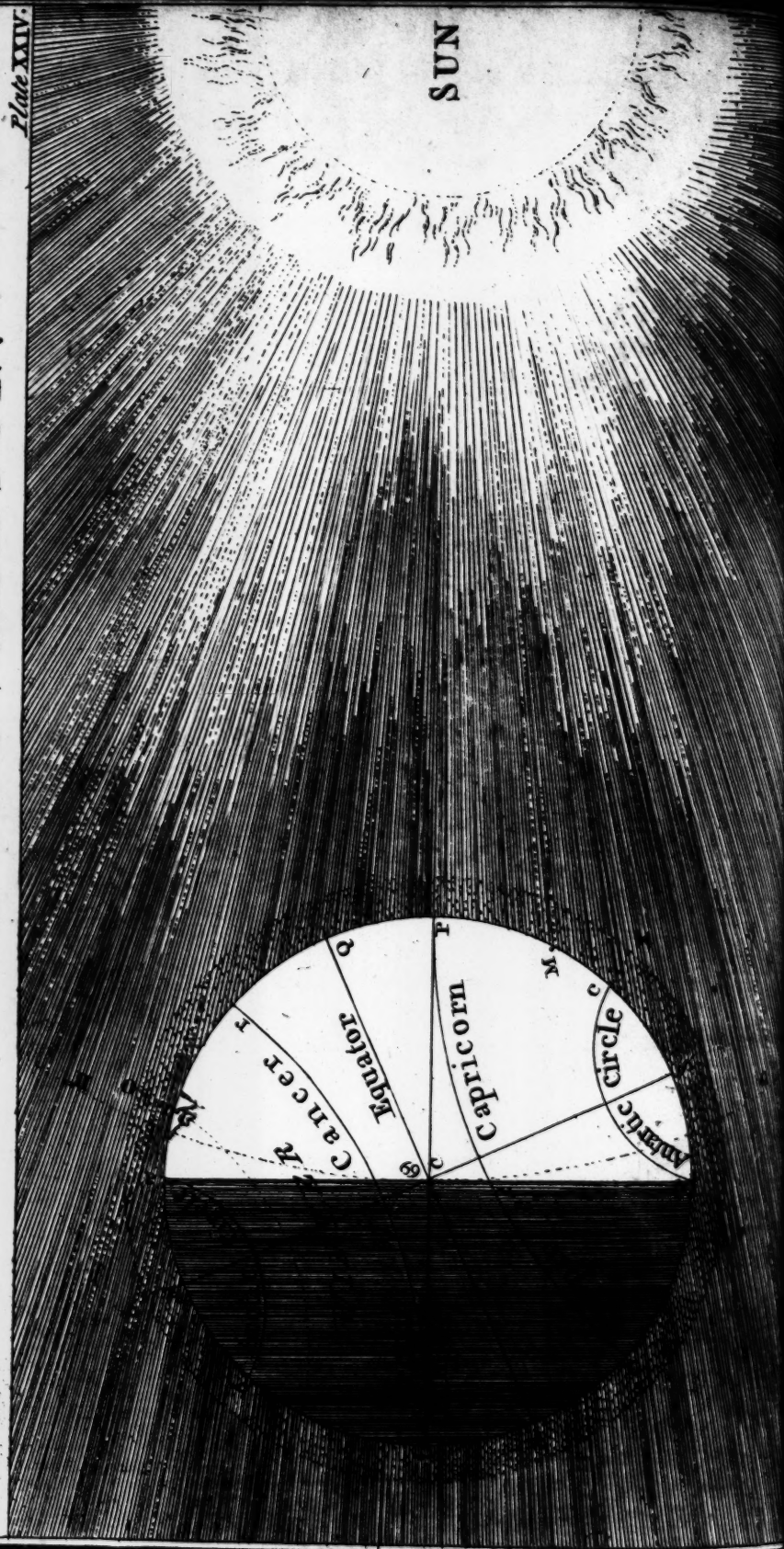
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THE WINTER SEASON.

Plate XIV.



Cleon. That which is called the *Harvest*, or *Shepherd's Moon*, is a very considerable *Phænomenon*; but I chuse to defer the Explication of it 'till we come to the Use of the *Celestial Globe*, where it will be much easier understood than by the *Orrery*.

Euphros. I am obliged to you, *Cleonicus*. — Is there any Thing more to be noticed at this Season of the Year? For I would not tire you with Impertinencies.

Cleon. I need not observe to you, that the Ancients made much more ado about this Season of the Year than we in this Age. They had now their Festivals of *Bacchus* and *Pomona*, the Deities of their Vintage and Orchards; and their extravagant Mirth, Rejoicings, and Revels, on these Occasions, ought rather to be suppressed, than related to the Disgrace of our Species. And it were to be wished, indeed, that the Harvest-Populace of the present Age were more sensible of the Dignity of human Nature; for they would then not debase it so much as they do, by some of their antique and ridiculous Customs at this Season of the Year in many Parts of *England*. — But we shall dwell no longer on this disagreeable Topic.

D I A L O G U E XII.

Of W I N T E R.

Cleonicus.

YOU now observe, my *Euphrosyne*, the *Autumnal Season* is over, in the *Orrery*, and the *Winter* begins; which brings on the cold Conclusion of the Year.

Euphros. I can scarce help shuddering at the Mention of Winter; and methinks, the northern Parts of the Globe seem to enter upon a horrid State — Gloom and Darkness are now their Portion — They are turning farther and farther from the Sun, which now begins to cheat the inferior Regions of the Earth. — How dismal is the Face of Winter, even in Machinery!

I i

Cleon.

Cleon. A heavy and dreary Season, indeed! The Sun, as the Earth moves towards *Cancer* (ϖ), declines from its meridian Height, and the Polar Parts go gradually into Darkness; till at length, when the Earth is got to *Cancer* (ϖ), the northern frigid Zone will be over-whelmed in Obscurity, like that of the Evening Twilight.

Euphros. So I observe. — And at the same Time, I see the southern Pole, and its Regions, become more and more illuminated; and when the Sun has reached *Cancer*, I suppose the whole polar Circle will enjoy its Light uninterruptedly for a While.

Cleon. It will so for one Day; and then the Sun will begin to leave the Pole, and the Parts about it by Degrees. — Thus all Things will appear reverse to what they were in the Summer Season. — The Days are short, and the Nights long; which you plainly discern by the northern Parallels continuing but a short Time in the Light, or illumined Hemisphere, and a much longer Time in the Dark one. — And therefore, by a natural Consequence, the Cold must greatly increase in all north Latitudes, and this, together with the Shortness of Days, constitute the Nature of this Season, and make what we call *Winter*; which is one great Cause of the encreasing Coldness of this Season.

Euphros. You have already taught me to understand, that as the Sun's Rays falling more directly on us in Summer helped to augment the Heat of that Season; so his Rays falling now more obliquely on our Parallel, and all the northern ones, conduce to increase the Cold, and render it more intense.*

Cleon. Very good, you remember and apprehend the Thing well. — But see, the Earth has now reached the critical Point,

* The Reader, by casting his Eye on the Diagram in Plate XXIV, will see an exact and natural Representation of the Earth in its Winter-Situation in the Orrery, and such as it really has in its Orbit, with respect to the Sun, in the Middle of Winter; from whence as easy an Idea of the concurring Causes of Cold in this Season may be collected, as from a View of the Earth itself in the Machine; and indeed there is no other Way by which this important Affair can be so justly and naturally represented to the Understanding. I hope no one will think he has too much Assistance in a Matter so little understood, as the *Rationale of the Seasons*.

Point, I mean the Beginning of *Cancer*, ——— and now is the Depth of Winter to all the northern Latitudes, and the Height of Summer to all the southern Parts. ——— The Sun, you observe, appears now to enter *Capricorn* (*ꝛꝛ*). ——— The highest Part of the enlightened Hemisphere, you see, reaches but to the *Arctic Circle*, and leaves all beyond it to the Pole in Darkness, or rather Twilight. ——— For, as I shall shew you hereafter on the Globe, there are but *five Degrees* about the Pole, which are now in absolute Darkness.

Euphros. Well, 'tis very admirable to see Nature thus mimicked and represented by Art! To see the Change and Succession of Seasons all performed in so short a Space, is wonderful and delightful. ——— The Earth, I see, is advancing a-pace towards the *Vernal Equinox*, whence it first set out; and there our artificial Year will end.

Cleon. It will; ——— and as the Earth moves on, you'll see, by Means of the Parallelism of the Earth's Axis, how all the northern Parts of the Pole are gradually turned towards the Sun again, and re-enjoy his Beams; — how the Days lengthen, and the Nights decrease, contrary to what happens beyond the Equator; — and how the chilly, darksome Season moves off, succeeded by the smiling Spring. — The Qualities of this Season afford a copious Theme to the Poets; among whom we find many beautiful Descriptions of Winter; the first and principal of which is that of old *Homer*, in his 12th *Iliad*, which is thus,

*As when sharp Boreas blows abroad, and brings
The dreary WINTER on his frozen Wings;
Beneath the low-hung Clouds the Sheets of Snow
Descend, and whiten all the Fields below.*

And a little after;

—— High Jove his sharp Artillery forms,
And opens his cloudy Magazine of Storms;
In Winter's bleak uncomfortable reign,
A snowy Inundation hides the Plain;
He stills the Winds, and bids the Skies to sleep;
And pours the silent Tempest thick and deep:

*And first the Mountain-Tops are cover'd o'er,
 Then the green Fields, and then the sandy Shore;
 Bent with the Weight, the nodding Woods are seen,
 And one bright Wast hides all the Works of Men.
 The circling Seas alone absorbing all,
 Drink the dissolving Fleeces as they fall.
 So from each Side increas'd the stony Rain,
 And the white Ruin rises o'er the Plain.*

Euphras. This is very beautiful, indeed! Pray, what does *Virgil* say on this cold Subject?

Cleon. The Theme is a frozen one, 'tis true; but it does not abate the Poet's Fire. — For he very copiously describes the Winter and all its various Incidents in the following admirable Manner; where speaking of the northern Climates, he gives us the Description of a *Scythian* Winter in the subsequent Lines.

*Early they stall their Flocks and Herds; for there
 No Grass the Fields, no Leaves the Forests wear:
 The frozen Earth lies bury'd there, below
 A hilly Heap, sev'n Cubits deep in Snow;
 And all the west Allies of stormy Boreas blow.
 The Sun, from far, peeps with a sickly Face;
 Too weak the Clouds, and mighty Fogs to chase;
 When up the Skies he shoots his rosy Head,
 Or in the ruddy Ocean seeks his Bed.
 Swift Rivers are with sudden Ice constrain'd;
 And studded Wheels are on its Back sustain'd.
 An Host now for Waggon, which before
 Tall Ships of Burden on its Bosom bore.
 The brazen Cauldrons with the Frost are flaw'd;
 The Garment, stiff with Ice, at Hearths is thaw'd;
 With Axes first they cleave the Wine, and thence,
 By Weight, the solid Portions they dispense.
 From Locks, uncomb'd, and from the frozen Beard,
 Long Isicles depend, and crackling Sounds are heard.
 Mean Time, perpetual Sleet, and driving Snow
 Obscure the Skies, and hang on Herds below:*

*The starving Cattle perish in their Stalls,
Huge Oxen stand inclos'd in wintry Walls
Of Snow congeal'd; whole Herds are buried there
Of mighty Stags, and scarce their Horns appear;
The dext'rous Huntsman wounds not there a-far,
With Shafts or Darts, or makes a distant War
With Dogs; or pitches Toils to stop their Flight;
But close engages in unequal Fight.
And while they strive, in vain, to make their Way
Through Hills of Snow, and pitifully bray;
Assaults, with Dint of Sword, or pointed Spears,
And homeward, on his Back, the joyful Burden bears.
The Men to subterranean Caves retire;
Secure from Cold, and crowd the chearful Fire:
With Trunks of Elms and Oaks, the Hearth they load,
Nor tempt th' Inclemency of Heav'n abroad;
Their jovial Nights in Frolic and in Play
They pass, to drive the tedious Hours away,
And their cold Stomachs with crown'd Goblets cheer,
Of windy Cyder, and of barmy Beer.
Such are the cold Raphëan Race; and such
The savage Scythian, and the German Dutch;
Where Skins of Beasts the rude Barbarians wear,
The Spoils of Foxes and the furry Bear.*

Dryd. Virg. Georg. III.

And thus Sir Richard Blackmore.

*At length, forsaken by the solar Rays,
See blooming Nature sickens and decays,
While Winter all his snowy Stores displays:
In hoary Triumph unmolested reigns
O'er barren Hills, and bleak, untrodden Plains.
Hardens the Glebe, the shady Grove deforms,
Fetters the Cold, and shakes the Air with Storms;
Now active Spirits are restrain'd with Cold,
And Prisons cramp't with Ice the genial Captives hold.
The Meads their flow'ry Pride no longer wear,
And Trees extend their naked Arms in Air;*

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*The frozen Furrow, and the fallow Field,
Nor to the Spade, nor to the Harrow yield.*

Creation, Lib. II.

The Approach of *Winter* is also thus admirably represented by Mr. *Thompson*, on the Seasons.

*Now when the chearless Empire of the Sky
To Capricorn the Centaur Archer yields,
And fierce Aquarius stains th' inverted Year;
Hung o'er the farthest Verge of Heav'n, the Sun
Scarce spreads o'er Æther the dejected Day.
Faint are his Gleams and ineffectual shoot
His struggling Rays, in horizontal Lines,
Thro' the thick Air; as cloath'd in cloudy Storm,
Weak, wan and broad, he skirts the southern Sky;
And, soon descending, to the long, dark Night,
Wide shading all, the prostrate World resigns.
Nor is the Night unwish'd; while vital Heat,
Light, Life, and Joy the dubious Day forsake.
Mean Time, in sable Tincture, Shadows vast,
Deep-ting'd and damp, and congregated Clouds,
And all the vapoury Turbulence of Heaven
Involve the Face of Things. Thus Winter falls
A heavy Gloom, oppressive o'er the World,
Thro' Nature shedding Influence malign,
And rouses up the Seeds of dark Disease.
The Soul of Man dies in him, loathing Life,
And black with more than melancholy Views.
The Cattle droop; and o'er the furrow'd Land,
Fresh from the Plough, the dun, discolour'd, Flocks,
Untended spreading, crop the wholesome Root.
Along the Woods, along the moorish Fens,
Sighs the sad Genius of the coming Storm;
And up among the loose disjointed Cliffs,
And fractur'd Mountains wild, the brawling Brook,
And Cave, presageful, send a hollow Moan,
Resounding long in list'ning Fancy's Ear.*

Euphros.

Euphros. Well, *Cleonicus*, the Pleasure which these Conversations on the Seasons afford me are inexpressible. Their Nature explained by the Orrery, and their Properties and Qualities as finely described by the Poets, give me perfect Ideas thereof; such as I should never have otherwise been able to have attained. — But see, the Year is compleated, and the Evening is spent. — The Machine may therefore rest for this Time. — And, pray, *Cleonicus*, what do you propose for the next Speculation?

Cleon. I purpose to shew you next, the *Theory of Day and Night*, the Alternation, and various Length of each, in every Season of the Year; and that in the same Manner by the Orrery, as I have explained to you the Seasons.

DIALOGUE XIII.

The THEORY of DAY and NIGHT, explained by the ORRERY.

Euphrosyne.

SO you think, *Cleonicus*, the Orrery the aptest and best Machine for explaining the Nature and Difference of *Night* and *Day*. —

Cleon. Undoubtedly, 'tis the best Instrument for that Purpose ever yet invented. For here you see the very Thing itself in Miniature. — Here the Taper is the Sun, illuminating one Half of this small, terraqueous Globe, which represents the Earth; having all the Parts of Land and Water duly represented on it, with all the Meridians and Parallels of Latitude. — As it moves in its annual Course, you observe it turns about its own Axis; and is furnished with an Hour-Circle and Index for measuring the Time. All which Things are now to be regarded in the Representation of *Day* and *Night* by the Machine.

Euphros. These Things I shall readily attend to. — Therefore, put the Machine in Order, for the Experiment, and I'll put to the Window-shutters to darken the Room. —

Cleon.

Cleon. Stay a little, 'till I have placed the Earth in its proper Position for shewing the shortest Night and longest Day of the Year; and that is, in the *Beginning of Capricorn*, when the Sun will appear to enter *Cancer*. — In the next Place, we will put a very small Patch on the Place of *London*, which, by its Rotation, will shew the Parallel of *London* (XYZ), described in each Revolution of the Earth about its Axis. — Lastly, to bring the Patch to that Part of the Meridian (X) which is opposite to the Sun; and set the Hour-Index at 12 precisely. — These Things being done, you may darken the Room as soon as you please, and then I'll put the Instrument in Motion.

Euphros. 'Tis done. —

Cleon. Observe the Earth equally divided into a light and dark Hemisphere, which represent *Day* and *Night*; as the Meridian passes over the Middle Part of each; so it shews the *Noon*, or *Mid-day* to all Parts under it at the one, and *Mid-night* to all Parts under it in the other; among which you see the Patch, or *London* (at X). — I'll now set the Machine a-going: — Observe the Earth revolving about its Axis from *West* to *East*.*

Euphros. I do, with Pleasure, behold it; and I observe, that the Position of the Earth's Axis is such, as will bring *London* soon out of the dark Hemisphere into the enlightened one.

Cleon. It will so; and I need not tell you, that that will be the Time from *Mid-night* to *Sun-rising*, or the Length of Half the Night, at that Time. Observe nicely the Time when the Patch begins to enter the Light.

Euphros. I will. — It will not be long I see. — It is now just come to the Point (O) or Circle of Light, — and the Index is at 3^h 47'.

Cleon.

* As some of our Readers may not have seen an Orrery, and others may not particularly remember the Phenomena of *Day* and *Night* which they saw represented in it, I have judged it necessary to add a Diagram thereof (in Plate XXIII.) to assist the Understanding and Memory, in which, by a bare Inspection, all the Variety of the Alternations of Day and Night in the Summer, Equinoxial and Winter Seasons, is, it is presumed, very easy to be understood; and in a good Measure, such a Print may supply the Want of an Orrery, or other Instrument for this Purpose.

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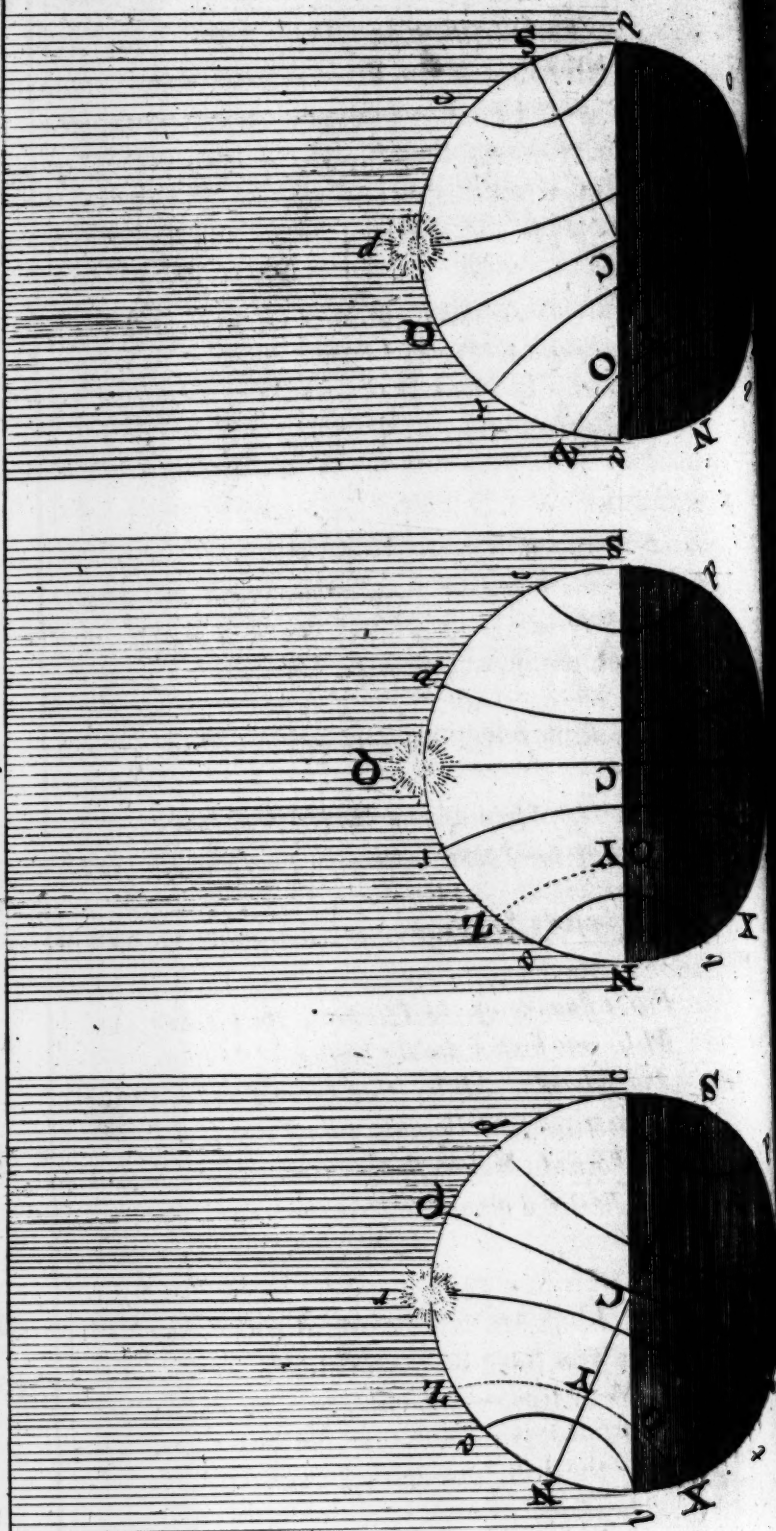
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The Different Lengths of DAYS & NIGHTS.

Plate XXIII.



Cleon. That is the *Time of Sun-rising* on the 10th of *June*, and is the Morning of the Day. — A Time very delightful in Summer, and is a favourite Theme with the Poets, who have all given us beautiful Descriptions thereof, particularly in the following Instances.

Thus *Virgil*,

*Now rose the ruddy Morn from Tithon's Bed,
And with the Dawn of Day the Skies o'erspread ;
Nor long the Sun his daily Course withheld,
But added Colours to the World reveal'd.*

Thus *Garth*,

*Aurora, on Etesian Breezes borne,
With blushing Lips breaths out the sprightly Morn.
Each Flow'r in Dew their short liv'd Empire weeps,
And Cynthia with her lov'd Endymion sleeps.*

And *Homer* thus finely personates the Morn in the following Distich :

*Now rosy Morn ascends the Court of Jove,
Lifts up her Light, and opens Day above.*

Also *Mr. Thomson's* Description of *Sun-rising* is too fine not to be taken Notice of.

*Fierce flaming up the Heavens, the piercing Sun
Melts into limpid Air the high-rai'd Clouds,
And Morning Mists, that hover'd round the Hills,
In parti-colour'd Bands ; till all uncoil'd
The Face of Nature shines, from where Earth
Far-stretch'd around to meet the bending Spheres.*

Seasons. 74.

Euphros. These are very beautiful and natural Descriptions, which, while you have been repeating, the Patch has got good Part of the Way towards the Meridian of Noon.

Cleon. I see it is — and thus the Sun rises gradually higher and higher to the Inhabitants of *London*, till the Patch comes under the Meridian (at z) where the Sun is at its greatest Meri-

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dian Height in the Tropic of *Cancer* (at *r.*) This makes the Noon of the Day thus admirably described by the last mentioned Poet.

'Tis raging Noon ; and, vertical, the Sun
Darts on the Head direct his forceful Rays
O'er Heaven and Earth, far as the ranging Eye
Can sweep, a dazzling Deluge reigns ; and all
From Pole to Pole is undistinguish'd Blaze.
In vain the Sight, dejected to the Ground,
Stoops for Relief ; thence hot ascending Steams
And keen Reflection pain. Deep to the Root
Of Vegetation parch'd, the cleaving Fields
And slipp'ry Lawn an arid Hue disclose,
Blast Fancy's Blooms, and wither even the Soul.
Echo no more returns the chearful Sound
Of sharp'ning Scythe : The Mower sinking heaps
O'er him the humid Hay ; with Flowers perfum'd,
And scarce a chirping Grass-hopper is heard
Thro' the dumb Mead ; distressful Nature pants.
The very Streams look languid from afar ;
Or thro' th' unsbelter'd Glade, impatient, seem
To hurl into the Covert of the Grove.

Seasons, Page 81.

Euphros. It is now just Noon in the Orrery, but far different from that you have now been describing. — Here every Thing is quiet and serene ; no scorching Sun, no sweating, fainting Swains. — How inoffensively, as well as pleasant, is the most irksome Part of the Day here represented by Art !

Cleon. Very true, Sister ; we here observe the Hours of a Summer's Day pass without the Fatigue and Pain of enduring it. — But Night comes stealing upon us ; the Patch approaches the Confines of Darkness, and the Sun as gradually declines. — You will observe, it takes the same Time in passing over this Half of the enlightened Hemisphere as it did the other, viz. $8\frac{1}{4}$ Hours nearly ; which, therefore, makes the longest Day $16\frac{1}{2}$ Hours at London.

Euphros.

Euphros. I see what you say is Fact. — The Sun is now just entering the Shades ; and the Index points at viii. 13. — How consistent is Art with Nature !

Cleon. Nature is the Contrivance of an infinitely wise Artist ; if we poor Mechanics can fabricate an artificial World so exactly, it is Nothing wonderful to see such Beauty, Order, and Harmony in the Mundane System. —

The Close of the Day is thus beautifully described by *Hom. r* :

*As when the Morn, refulgent Lamp of Night,
O'er Heav'n's clear Azure spreads her sacred Light.
When not a Breath disturbs the deep Serene,
And not a Cloud o'ercasts the solemn Scene :
Around her Throne the vivid Planets roll,
And Stars unnumber'd gild the glowing Pole,
O'er the dark Trees a yellower Verdure shed,
And tip with Silver ev'ry Mountain's Head ;
Then shine the Vales, the Racks in Prospect rise,
A Flood of Glory bursts from all the Skies ;
The conscious Swains rejoicing in the Sight,
Eye the blue Vault, and bless the useful Light.*

The Setting of the Sun is thus elegantly described by *Mr. Thomson*.

*Low walks the Sun, and broadens by Degrees
Just o'er the Verge of Day. The rising Clouds
Assembled gay, a richly gorgeous Train,
In all their Pomp attend his setting Throne :
Air, Earth, and Ocean smile immense ; and now,
As if the weary Chariot sought the Bow'rs
Of Amphitrite ; and her tending Nymphs,
(So Grecian Fable sung) he dips his Orb ;
Now half immers'd ; and now a golden Curve
Gives one bright Glance, then total disappears.*

This is followed by a Description of a Summer's Evening in these Words.

*Confess'd from yonder slow extinguisht Clouds,
All Æther soft'ning, sober Evening takes
Her wonted Station in the middle Air ;
A thousand Shadows at her Beck. First this*

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*She sends on Earth; then that of deeper Dye
Steals soft behind; and then a deeper still,
In Circle following Circle, gathers round,
To close the Face of Things. A fresher Gale
Begins to wave the Wood, and stir the Stream;
Sweeping with shadowy Gust the Fields of Corn,
While the Quail clamours for his running Mate.
Wide o'er the thirsty Lawn as swells the Breeze,
A whit'ning Flow'r of vegetable Down
Amusive floats.*

Euphros. These Descriptions are like the Poetry of Mr. Thompson, where every Thing is extraordinary. — As you have shewn me the *Morning, Noon, and Night* of the *largest Day* in the Orrery; let us now see the gradual Alterations which happen in regard thereto, while the Earth passes on to the Winter Season.

Cleon. That shall be done, and is easy by setting the Machine in Motion. — See the Earth moving on towards *Libra*, and at the same Time revolving about its Axis. — And as it advances, you see the Circle bounding Light and Darkness (*bc*) continually approaching towards the Poles (*N S*) and that the Patch, representing *London*, has its *diurnal Path* (*z o*) in each Rotation, constantly decreasing, while the nocturnal One (*ox*) is increasing as gradually, till at last they come to an Equality in *Libra* $\simeq$.

Euphros. All this I see with great Pleasure, — and waiting a little, shall soon find the Earth in *Libra*: — There seems now to be but a small Difference between the diurnal and nocturnal Tracts of the Patch.

Cleon. Very little; — it is now scarcely visible. — The Earth has just reached the Point, where I will cause it to move very slow, that you may better view the Appearances of the *diurnal Motion*.

Euphros. Very good; — I see a perfect *Equality of Night and Day*, by Means of the Index and the Patch; viz. 12 Hours each. — At the same Time, I observe the Reason of this to be, that the Sun is in the Equinoctial at this Time; and, consequently, as all the Parts of the Earth have the diurnal Motion

parallel thereto; and the Circle, bounding Light and Darkneſs, paſſes thro' the Poles; ſo half that Motion muſt be performed in the enlightened Part, and the other Half in the dark, for every Part between the Equinoctial and the Poles; and, therefore, Day and Night muſt needs be equal now over all the Earth.

Cleon. You have a very juſt Notion of the Matter; and can account for all the Phænomena of *Day and Night*, I believe, in any Situation of the Earth, or Season of the Year. We will only, therefore, take a View of a Rotation or two of the Earth in the firſt Point of *Cancer*; that is, in the Miſt of the *Winter Season*. — Towards which you ſee the Earth advances with an accelerated Motion in her Orbit, and conſequently about her Axis. — As *Autumn* paſſes off, you ſee *Winter* gradually coming on. — The Days (with us) ſhorten, and the Nights increaſe; — the N. Pole, by Degrees, declines from the Sun, while the S. Pole accedes nearer and nearer thereto.

Euphrof. It is all very evident, indeed, *Cleonicus*; — I ſee the enlightened Hemisphere gradually remove from the N. Pole, and take in the Southern; and conſequently all the Parallels of N. Latitude have their diurnal Parts decreaſing, and the nocturnal increaſing; the Contrary of which I obſerve happening in the Southern Parallels. — But ſee, the Earth has reached the Beginning of *Cancer*, let it be ſtopped there a while, to obſerve more nicely the Phænomena of the diurnal Motion, in this dreary Season,

Cleon. I will ſtop the annual Motion, and continue the diurnal One at ſuch a Rate, that you may make your Obſervations with Eaſe and Pleaſure. —

Euphrof. The firſt Thing I obſerve is, that the Circle of Illumination extends but a little farther than the Patch towards the North; and, therefore, the Path deſcribed by it in the enlightened Hemisphere is but very ſmall in Compariſon of the Diſtance it goes thro' the dark One; but their Diſtances I can meaſure in Time, by bringing the Patch upon the Meridian, and placing the Hour Index at 12, as before. — Thus, as the Earth revolves, I obſerve the Patch, or the City of *London*, enters the enlightened Hemisphere a few Minutes after 8 in the Morning; which, therefore, is the Time of Sun-riſing to us, and goes out of it as much before 4 in the Afternoon; whence I ſee, that the ſhortest

shortest Day is not quite 8 Hours long, and consequently not half the Length of the Night.

Cleon. You observe the Position of the Earth is just the Reverse now to that which it had in midsummer Season, or when the Earth was in the opposite Part of its Orbit; and, therefore, not only the Seasons, but the Length of Days and Nights will be just the Reverse of what they were then, and the very same which you may now perceive they are in the lower or southern Parts of the Earth, at the same Distance from the Equinoctial as we are.

Euphros. I readily perceive it, and I shall demonstrate it too by sticking another Patch upon the same Meridian, and in the same Latitude with *London*, on the southern Side. — Now the revolving Earth brings the southern Patch into the Sun-beams before the Hour Index points to 4 in the Morning, nor does it enter the darkened Hemisphere till after the Hand has past the Hour of 8 in the Evening. — I have now the Satisfaction to know by this Experiment how the Days and Nights come to be alternately equal in Winter and Summer, and also in the same Latitude on different Sides of the Equator. — I farther see, that the Inequality of Day and Night ceases at a certain Limit, beyond which, on one Side, they are only deprived of Light or Day, and the other, they enjoy the Sun-beams constantly for the same Time. — Those who live under, and about the North Pole, seem now to have a tedious, horrid Gloom, while those, who are in the southern Pole, have the Sun bright above the Horizon, and enjoy an uninterrupted Day. — How happy are we whom Providence has placed between two such disagreeable Extremes! For the Enjoyment even of Light itself, for a long Continuance, could not be pleasant, and Darknes is what all Mankind are naturally apt to shun.

Cleon. Your Reflections in these Respects are very natural; but we are to consider, at the same Time, how few of our Species have such a Situation in Life. By our late Discoveries, it is pretty certain that there are few, or no Inhabitants of the Regions of the southern Pole, it being in all those Parts a constant frozen Ocean; and with Respect to the northern Polar Regions, the Continent of *Europe*, *Asia*, and *America*, extend not far within them; and those, whose Lot it is to inhabit those dreary Regions,

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appear to be so wonderfully suited and adapted to them, that it is well known by Experience they prefer their native, gloomy Spot to any Part of our happier temperate Zone; nor are they so very much in the Dark perhaps as you may imagine, the Continuance of their Darknefs being proportioned to their Distance from the Polar Circle, and greateft of all at the Poles; but even there, the Moon affords them Light one half of the Time, and they enjoy a Twilight till the Sun is 18 Degrees below their Horizon; and it is very probable, that the Land does not extend so far as to admit of any Inhabitants within five Degrees and a half of the Pole, and to those who are farther off than that, there can be no dark Night at all.

Euphros. I am glad to hear of any Thing that can contribute to solace those unhappy Mortals in their joyless Situations; for I cannot help thinking they must be miserable there; — but I recollect the Kinds of Happiness and Misery are more Relative than Real; and I am the more convinced of it, when I consider that even our Negroes quit their native Soil only by Force, and are so naturally fond of their sable Complexion (at which I shudder almost as much as at Polar Darknefs) that I remember I have somewhere read, they paint the Devil white, to represent him so much the more terrible to Mankind.

Cleon. Whoever contemplates the Nature of Things in the Manner you now do, will find it very easy to correct many of the common, but very unjust Notions of Nature and Providence, and will come at last to the Conclusion, that infinite Beneficence in the divine Being could never permit the Creation of any Species of sensible Beings, without a Possibility of enjoying a proper Degree of Felicity peculiar to their several Natures. — But leaving those Digressions, we return to the remaining Season of the Year in the Orrery, which the Earth enjoys in passing from the first Degree of *Cancer* to *Libra*.

Euphros. And, consequently, while the Sun appears to go from *Capricorn* to *Aries*. — But what are the particular Phænomena that we attend to during this Interval?

Cleon. Nothing in particular, more than to observe the natural Transition from the Winter to the Spring Season; for when I give the Earth its annual Motion, and you see it proceeds in its Tour, you will plainly observe, that by Reason of the parallel

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Position of the Axis the northern Pole will gradually return and restore the Regions now in Darkness to the enlivening Influence of the Sun. — See it now moves on.

Euphros. I observe the Particulars you mention begin to appear in a very natural Manner. The Archs of the Parallel, that measure the Day, now gradually increase, and those which shew the Night of Course decrease in all the northern Latitudes. The Coldness of the Season, one would think, should now also abate, and every Day after the 21st of *December*, one might expect, should be warmer and warmer; but this does not quite tally with Nature; for you must have observed, *Cleonicus*, that *January* and *February* are oftentimes found to be the two coldest Months in the Year. Pray, how am I to understand the Reason of that?

Cleon. In a Manner as I heretofore hinted in relation to the Summer Heat; I then remarked to you, that the Summer's Heat was not greatest at Midsummer; and for the same Reason you are not to expect the Intensity of Cold by the Middle of Winter. The Causes of Cold continue much longer, *viz.* the different Length of Days and Nights, the Obliquity of the Sun's Rays, &c. still continue to produce Degrees of Cold, which, added to all that went before, the Aggregate, or Sum of All, will produce the greatest Degree of Cold in the Months you mention.

Euphros. I apprehend you clearly; — but see, the Earth has just now carried us thro' those Months; I am pleased to see the freezing Tropic left so far behind in the artificial Year, and the Return of the vernal Equinox so near at Hand. Nature seems now renewed even in the Orrery, and solar Beams diffuse themselves almost from Pole to Pole once more. — *London*, in its vicegerent Patch, now enjoys near equal Length of Days and Nights. — The Sun from the Earth appears in *Virgo*, and the Index shews him every Day advancing about one Degree forward. — Scarce any Difference now appears in the Length of the Day and Night. — The Circle of Illumination passes thro' both the Poles. — And now the Year is finished in the Orrery; for the Index points to the 20th of *March*.

Cleon. The Machine has now done you all the good Offices in its Power for the present; you have thereby seen in a short Time represented all the Phænomena of the Heavens; and what gives me a peculiar Pleasure, even beyond that of informing your

your Mind, is to find your Taste for Philosophy so true and just, that thro' so long a Series of Speculations on these Subjects they seem still entertaining and agreeable to you. — For to say that now, which at first I was not willing you should suspect, I was much in Doubt (tho' you expressed so great a Desire of being instructed in the *Celestial Science*) whether or no your Patience would hold out so long on one continued Subject. —

Euphros. So long, do you say, *Gleonicus*! On my Word, were you not my Brother, I should scarce forbear being affronted by such an Expression. — Patience for Instructions and Pleasures of this Kind! — Tired with contemplating the Powers and Works of Nature! — What did you take me to be, *Gleonicus*, once to think of my palling on those divine Subjects? — No, I remember too well what *Shakespear* says of the Wretch who cannot relish Music, “*He is fit for Rapines, Murders, &c.*” — How then must that unnatural Soul be characterised, that cannot always be delighted with the Music of the Spheres! with the Beauty and Harmony of the divine celestial Frame of Nature! That sublime, visual Music, thus represented by the same celebrated Poet. —

*Beauty is Music too, tho' in Disguise,
Too fine to touch the Ear, it strikes the Eyes,
And thro' them to the Soul the silent Stroke conveys,
'Tis Music heav'nly, such as in the Sphere,
We only can admire, but cannot hear.*

— Besides, do not the most judicious Divines and Philosophers tell us, that an infinite Scene of the Operations of divine Power and Wisdom will open itself gradually to our View in the future heavenly State, and that the Employment of Time to endless Ages will consist in an uninterrupted Intuition and Contemplation of the same? If so, how preposterous must it be, and contrary to the Character of a divine and rational Nature in us, to suppose it but even possible for a Person to meditate with Indifference on these Subjects, much less to think them tedious, tho' our whole short Life were constantly employed therein.

Cleon. What you say is certainly true, my *Euphrosyne*; but withal it must be observed, that in this imperfect present State, the Mind of Man is naturally apt to be fatigued with any Kind of constant Study; and we must always propose these Matters as Subjects rather of Amusement than the Business of Life; we are not here to know what perfect Happiness is; nor can we enjoy it in any Degree, unless under particular Restrictions, and as the Result of an agreeable Mixture and Variety of Incidents. Therefore we shall, for the present, leave those Fields of *Æther*, where Suns refulgent shine, and Planets and Comets go their ample and solemn Rounds; and descend to the nether Regions of *Air*, a stupendous Instance of divine Omnipotence; and whose wonderful Properties are highly worthy your Notice and Attention. There we shall see how every Part is duly ordered to render it as useful as it is necessary. — We shall find it the natural Means of Life to Animals and Vegetables. — The *Medium* for propagating Sounds. — The Method that Nature has taken to render all Objects visible unto us, by making it the general Receptacle of Light. — The *Medium* of Flying, and the Habitation of numberless Animals of the winged Kind. — That Medium which alone affords the proper *Pabulum* of Fire and Flame. — The Element and Essence itself of Winds, Storms, and Tempests. — The Medium in which alone Vapours and Exhalations can have any Existence. — And lastly, The natural Means and Cause of all Kinds of Meteors, watery or fiery, such as Fogs, Clouds, Rain, Snow, Hail, Thunder, Lightning, the *Aurora Borealis*, &c.



The Young GENTLEMAN and LADY's
P H I L O S O P H Y.

P A R T III.

P N E U M A T I C S:
O R,

The Nature and Properties of the AIR explained.
The Structure and Use of the AIR-PUMP, and other
Instruments.

A N D

The Doctrine of *Wind, Sound, Meteors, &c.*

D I A L O G U E I.

*On the Nature, Form, and Magnitude of the AT-
MOSPHERE, or Body of AIR.*

Euphrosyne.

ELL, you are resolved to make a Philosopher of
me, I find; you have brought me into a new Field
of Enquiry, and a very airy One too, *Cleonicus*.

Cleon. Indeed it is, Sister, literally so; you are
now to explore the Regions of the *Air*, and dwell, for some
Time, amongst the *Clouds*.

Euphros. That is, I suppose, in plain *English*, I must now
inform myself of the Nature of the Air, and its Use in the Sys-
tem of the World. ——— To this I shall address myself with
great Readiness and Spirit; especially as I know of nothing in
Nature that I have heard more about, and am less acquainted

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with, than this extraordinary unseen Something, you call Air,—
Pray, what Definition do you give to this Subject?

Cleon. The Air is defined to be *a fine, invisible, heavy, elastic, compressible Fluid, of a different Density, environing the Earth on every Side to an indefinite Height.*

Euphros. So many Characters entering into a bare Definition of it seem to make it an important Subject; pray, what are its general Qualities and Uses?

Cleon. I will tell you in a few Words.

The principal Property of the Air is its Weight or Gravity; for tho' a small Portion of it be light, yet, considering the great Height to which this Body of Air extends, the Weight of any Column of Air upon a given Surface must be very great. For by some Experiments that you will see hereafter, you will be easily convinced, that the Pressure of a Column of Air upon a Square Inch only is equal to *fifteen Pounds Weight.*

Euphros. Such an Experiment I shall gladly see; for, when you talk of such a Weight of the Air, I scarce know how to understand you, as I never yet experienced any Weight or Pressure in the Air at all; nor should I have thought of any such Thing, had it not been for what I have heard you and other Gentlemen speak of, when you have been talking of the *Air-Pump.*

Cleon. Most People say, and think as you do; they know little of this Matter for Want of the proper Means of being acquainted with it, and never fail of being wonderfully surprized, when they are told the Pressure of the Air upon the Surface of their Bodies amounts in general to at least *13 Ton Weight.*

Euphros. I don't wonder at their being surprized at such a strange Doctrine as this; for which Way is it possible a Person should sustain so prodigious a Pressure, and yet, at the same Time, be entirely insensible of it?

Cleon. This you will be satisfied of when you consider, that the Air is a fluid Body, and you will be taught hereafter to understand, that all Fluids press with an equal Force every Way, as well upwards as downwards, Side-ways, and in all Directions you can conceive, and then, allowing that every square Inch upon a Man's Body sustains a Pressure of 15 Pounds, the
Pressure

Pressure upon the whole Surface will amount at least to 13,320 Pounds upon the Surface of a middle Size Man (as it is found by Computation) which is very nearly 14 Ton Weight.

Euphros. This is a Subject I cannot at present dispute with you; but if this be the Case, what I most wonder at, at present, is, how it comes to pass, that I am so far from apprehending any such great Weight from the usual Effects in all other Cases, that in reality I find nothing at all of it.

Cleon. The Reason of this strange Phænomenon, if I may so call it, is this, that our Bodies, as well as all others, are filled with Air throughout, and the Spring of this internal Air is a Force just equal to the Pressure of the Air without, and when two Forces equal to each other act in contrary Directions, they intirely destroy each others Effects; and any Body, being pressed with great Force from the ambient Air, is really in the same Case as if it was affected by no Pressure of the Air at all; of this too you will be made thoroughly sensible by Experiment.

Euphros. The Knowlege of such mysterious Things will be a very agreeable Acquisition; but pray, by the Way, tell me how the Air, a Substance which I can neither see nor feel, can be so heavy a Body.

Cleon. The Weight of the Air arises from the same common Cause as the Weight of any other Body does, viz. from that Power, or Force in Nature which is usually called *Attraction*, or *Gravitation*. This Power, as Sir *Isaac Newton* tells us, equally affects all the Parts of Matter, and produces in them a Tendency towards each other; and this Tendency or Force is that which we call the *Weight* of any Body. Thus, what we commonly call the Weight of a Stone is only its Endeavour to fall, or approach towards the Body of the Earth, and thus every Particle of Air endeavours equally to fall towards the same Surface of the Earth, and therefore the Sum of all those Forces, in all the Particles, make a considerable *Sum Total of Weight*, or *Pressure* in the Air.

Euphros. If then the Particles of Air are like so many Stones, why then do they not fall like the Stones, and all abide upon the Surface of the Earth? Whereas, on the contrary, you tell me,

me, that they fill a very great Space in the circumambient Regions.

Cleon. In order to answer this Question, which you have very properly proposed, you must be acquainted with one other Power in Nature, by which the Parts of Matter, when they are at a certain very small Distance from each other, are made to *repel*, or *fly* from each other; and this is what the Philosophers usually call the *repulsive Force*, or *Elasticity* in the Parts of Matter. The Force which I before mentioned under the Title of Gravitation, is, with Respect to the small Particles of Matter, called the Attraction of Cohesion, or it is that divine Power in Nature which so affects the Parts of Matter, that while they are in Contact, or can touch each other, they are by this Means made firmly to cohere or abide together, and according to the different Figures of the Parts of Matter, this Power will produce a greater or lesser Degree of the Force of Cohesion, which is the general Cause of all Degrees of Hardness or Softness in Bodies, and what we usually call Fixity and Fluidity. But more of this Subject hereafter. The Parts of Matter, as I said before, when they are once beyond the Sphere of this attracting Force, are found to be strongly actuated by the repelling Force; and this is the Case of Air, the Parts of which do constantly repel each other, and therefore those which are next to the Surface of the Earth will prevent the other Particles above them from coming so near to it by their repulsive Force or *Elasticity*; and this is the *second great Property of the Air*.

Euphras. By this second Property of the Air, which you call Elasticity, I suppose, if I understand you right, the Parts of Air are kept a Distance from each other; but still it is not clear to me how this can be the Case; because of the great Weight of the Air, which one would think should precipitate those Particles at once down to the Surface of the Earth. Pray, why is not this the Case?

Cleon. Because the Elasticity of the Air is a Force superior to that of Gravitation; or in other Words, the repelling Force in the Parts of Air which keeps them asunder is greater than the attracting Force between the Earth and those Particles by which they tend toward the Earth, and at a proper Time you will

will understand, that this repulsive Force is the strongest Power in Nature ; that these two Principles *an attracting and repelling Force* are the efficient natural Causes of all the Appearances in Nature ; and that the Properties, Qualities and Effects of all Bodies entirely result from them.

Euphros. But if the Parts of Air do repel each other, as you say, with so great a Force, how comes it to pass that we have any Air at all ? Why does not this elastic Force drive all the Particles of Air quite away ? What do you find confines them hovering round this Ball of Earth ?

Cleon. Your Question is *à propos*, Sister ; but still you are to consider, that the Power of Gravity is very considerable, tho' not entirely equal to the Elasticity of Air, and prevents this latter Force from having its full Effect. Were the Power of Gravity for a Moment to be suspended from Matter, and the Power of Elasticity to remain, the Atmosphere, or Body of Air, like a Parcel of Gun-powder set on Fire, would instantly be dissipated thro' the infinite Regions of Space ; but by Means of Gravity, by far the greatest Part is detained near the Surface of the Earth, and the Distance between the Particles only lessened ; and more so, as the Particles of Air are nearer to the Earth. For at a greater Distance they are less affected by the Power of Gravity, and are less heavy, and therefore the Effect of Elasticity will be greater, or keep the Parts of Air at a greater Distance from each other ; and thus it will be easy to understand, that the farther you go from the Surface of the Earth, the greater the Distance will be found between the Particles of Air ; and the nearer the Surface of the Earth, the less those Distances ; and this lesser or greater Distance between the Parts of the Air is usually called its *Density*, or *Rarity* ; for the less the Distance is, the greater will be the Number of Particles in the same Space, and the Air is, in such a Case, said to be *more dense* : On the Contrary, the greater the Distance between the Particles, and the Air, in such a Case, is said to be *more rare* ; from whence it will appear, that the Density of the Air in any Part will be always in Proportion to the Weight of that above, and consequently, greatest of all at the Surface of the Earth : Likewise, from these Principles it will follow, that the Weight of the Air and its elastic Force are always equal to each other, and

and therefore produce an universal *Equilibrium* among the Particles of Air in every Part of the Atmosphere.

Euphros. According to this Account of the Density and Rarity of the Air, what Idea can I form of the Height of it? For, if the less the Air be compressed the more it is expanded, and the farther you go from the Surface of the Earth, the less that compressive Force will be, where am I to conceive the Bounds or Limits of the Atmosphere to be?

Cleon. No where at all; for the Parts of Air in the upper Regions will be expanded to Infinity, 'till at Length we may very properly understand, that the Atmospheres of every Body in each System, and of all the Systems in the Universe, meet with each other in the distant Spaces between, and mixing together, constitute that fine *æthereal Medium* which fills the Abyss of Space.

Euphros. This is a wonderful Doctrine; but it certainly must be as you say from the Nature of Things, as you have now explained it. Therefore, I apprehend it will be in vain to enquire about the Height of the Atmosphere, or Body of the Air.

Cleon. All that can be said in respect to the Height of the Air, is this, that the Density of it, at the Height of about 45 Miles, is but just sufficient to inflect, or bend a Ray of Light out of its right-line Course, which is the least Effect it can produce, and therefore all beyond that Height must be esteemed an unresisting *Æther*.

Euphros. As the Air is such a very extraordinary Substance, and possessed of such wonderful Qualities, how comes it to pass, that we can see nothing of it? For if it was not sensible otherways, I should know of no such Thing by the *Sight*.

Cleon. Why even in this Respect you may not be free from Mistakes. The Air in some Cases, tho' very rarely, is 'subject to the Sight, or may be perceived by the Eye; but as this seldom happens, we look upon the Air in general as altogether invisible; and it is necessary it should be so; for, as it is the Medium thro' which we see Objects, if the Parts of Air were in the least Degree perceptible, it would render the View of those Objects less perfect and distinct; as is well known by the Experiment of viewing Objects thro' a Telescope, which magnifies to a very great Degree; as it shews the Body of Air, so it renders

ders the View of other Objects more confus'd, and indistinct, which plainly convinces us of the Wisdom of the divine Architect in rightly disposing this Part of the Constitution of the World.

Euphros. But you was just now mentioning some particular Case in which the Air becomes visible; pray, what is that? For I shall have a great Inclination to have a View of so rare a Spectacle.

Cleon. That you may do under the following Circumstances: In a very hot Summer's Day, take a Walk to some open Parts of the Country, and place yourself upon an Eminence or rising Ground, in a Situation nearly facing the Sun; then, if there be any gentle Wind, or Motion of the Air, it will be shewn by Reflection of Light from the Body of the Air in the Vale below, and you will as perfectly see the Undulations or Waves of Air, almost, as you may those of Water agitated by a gentle Wind.

Euphros. This will afford me a particular Satisfaction, and I shall take the first Opportunity to gratify myself in this Respect; and then I shall know by Experiment, what I otherwise find, *that Wind is only Air in Motion.*

Cleon. It is very true, Sister: You have hit off the whole Philosophy of Wind at once. For supposing the Air was perfectly quiescent or stagnant, there would be no Wind at all; but as the Degrees of Motion, or Agitation in the Body of Air are greater or lesser; so we find stronger or weaker Winds arise; and as the Motion of the Air is this Way or that, so we usually say, the Wind blows from one Quarter or the Other, or from one Point of the Compass or another.

Euphros. Pray, what are the general Causes of Wind, or this Motion of the Air that you speak of?

Cleon. The particular Causes of Wind are many; but one general Cause is the Inequality of Heat and Cold in different Parts of the Atmosphere; but this will prove the entire Subject of a future Conversation. And as it will be proper, not only to tell you, that the Air has such and such Qualities, but to convince you by Experiments, that they do really exist, I shall make some Preparation for that Purpose against the next Opportunity; and so for the present, Adieu.

DIALOGUE II.

Of EXPERIMENTS to shew the natural Production of AIR.

Euphrosyne.

SO! You have spread the Table, I see, for my Entertainment. I can assure you, to feast my Mind on these Things affords me as much greater Pleasure than the common Productions of a Cook's-shop can afford the Palate, as the Subject of the finest Parts of Philosophy can be supposed to exceed all the Merits of the Art of *Pastry*.——I make this Sort of Comparison (which I know you will allow to be just) because I was the other Day in Company, where a certain Person, having just before displayed his Talent in descanting upon what was *fine Eating and Drinking*, and how happy it was to have a critical Taste to distinguish the Delicacies of a *Haut Goût*, and the genuine Flavours of *Burgundy* and *Champaign*, which took up the best Part of Dinner-time, and an Hour after; at length, he was pleased to direct his Discourse to me, and with an Air of Pleasantry to tell me, that he heard I was intent on the Studies of Philosophy, and that I was already become a very considerable Adept in it; that I had long been conversing with the Stars, and after much more of such Kind of complaisant Raillery, he added (by Virtue of a Bumper of *French Port*) that it had quite opened a new Scene to his View; that he had always looked on the Fair-Sex till now in a different Light; and that their highest Pretensions were to no more Skill than the *Oeconomy of a Kitchen*; and the pretty Dexterity of making *Puddings and Pies*.——It will not be worth while to insist on what farther passed between us; but though I was in some Measure affected by such a fashionable Piece of Ridicule; yet I considered, that Philosophy was too amiable a Science to be bantered out of my Regard for it, setting aside the natural Propensity that I always had to the Study of it; therefore let me not interrupt you any longer, but proceed to your Experiments; for I must still long to be acquainted with the Nature of this necessary Element, and learn how, and by what Means it is produced.

Cleon.

Cleon. It is Pity that any, even of our Sex, should so far betray their Want of Prudence as to ridicule a philosophical Disposition in Others, only for Want of a Taste for the Science themselves. I must allow this is but too often the Case; I only wish one Thing for the Honour of our Sex, that many of them had but half the natural Genius and Capacity of Improvement in natural and mathematical Sciences as many of the Ladies are possessed of:——But to the Purpose; you remember, I told you, when we last conversed together, that the Parts of Matter by *Attraction and Repulsion* were put into Motion, and that whenever by this Means they could be separated beyond the Sphere of Attraction, they commenced a repelling State, and then, as they were at a greater Distance from each other than before, they must become very light, and arise into the Body of the Air in Forms of Vapours and Exhalations of various Kinds. Those elastic Particles that rise visible to the Sight are what we usually call Vapours, or Steam; such as we commonly see rise from the Surface of heated Water and other moist Substances.

Euphros. This I am convinced of every Day by my Tea-kettle, in which I have often wondered at that Violence and Impetuosity with which it issues from the Spout; and I now begin to see somewhat of the Reason and Cause thereof, viz. that it arises from the Elasticity of its Parts, which by Experience I know is greatly augmented by Heat; but can you tell the particular Manner in which that is effected?

Cleon. As I shall shew hereafter, that all Heat consists in the great Velocity or swift Motion of the Parts of Matter, and the Velocity of the Particles of Light is the greatest of any, which we know of in Nature; so we find, that those Particles by their Action always produce the Sensation of Warmth or Heat, and being plentifully imbibed by all Kinds of Bodies, these active Particles are constantly employed to separate the Parts of Bodies, and by this Means to produce the natural Exhalations or Steams from every heated Liquor. These sensible Vapours rise into the Air, and make a Part of the Atmosphere; for the Air is constantly filled with Particles of Moisture, which by Heat are so far attenuated as seldom to be sensible to the Sight.

Euphros. Then what you now say, I presume, is the Reason why in the Morning or Evening, when the Air is cool, we see

the Vapours arise from the Earth into the Air, and also in a very cold Winter's Day, our very Breath becomes visible to the Eye, as it then wants a sufficient Degree of Heat to rarify the Particles, and make them escape the Sight.

Cleon. You understand this Matter very well; and in the same Manner you are to imagine, that solid Bodies will have their superficial Parts separated by the Action of Heat, and these Particles so separated will be affected with a repulsive Force; which repulsive Force will cause them to ascend into the Body of Air, and become a Part of the Atmosphere itself. These Particles arising from solid Bodies are always too fine to be visible to the Eye, and therefore it is, that we rarely know, or even think of any such Thing, and we find by Experience, that all Bodies lose their Parts in Proportion as they are more actuated by the Power or Particles of Heat; and when the Degree of Heat is very intense, there are but few Bodies, whose Parts are so fixed, or cohere so firmly, as not to be separated by their Action; and the Experiment which I shall now shew you, will be a sufficient Confirmation of this Truth.

Euphros. Pray, to what Purpose is this fine Pair of Scales and these several Slips of Paper, which I see, and the Wax-candle? I suppose, they are all to be concerned in the Experiment you mention.

Cleon. 'Tis true they are: The Candle is to shew you the great Power of Heat, or Fire, upon the Parts of those Pieces of Paper while they are burning, and they are all first weighed very nicely by those Scales. The Quantity which I have here provided weighs just 100 Grains, as you see by placing the several Slips in one Scale, and the Grain-weights in the other.

Euphros. I see they just equipoize each other; but how am I to know what Parts are converted into Air in burning?

Cleon. By weighing the Ashes which remain; for these we can collect, and place in the Scale without the Loss of a single Particle.——Thus, I take the first, and put it to the Flame of the Candle; it takes fire, and regularly burns down to my Finger; the Parts, you see, all fly off in Flame, except that fixed and earthy Part which is called the *Calx*, and which I now place in the Scale.——Then I take the Second, and burn it accordingly, and put the remaining *Calx* to the other in the Scale:——

And

And in this Manner I proceed with them all : ——— And now, my *Euphrosyne*, you see all their *Ashes* in the Scale, and you will observe how light they are ; you take out the former Weight of the Paper before it was burnt, and put in Others to make an Equilibrium with the *Ashes*, and you find, that 6 Grains is sufficient for that Purpose.

Euphros. I see that is the Case : A 100 Grain's Weight of Paper is now reduced to six only ; I can easily understand from thence, that 94 Parts of a 100 of this Paper has been driven into the Air by the Action of Fire, and so much of the Paper, I presume I may say in the philosophical Stile, is *converted* into Air.

Cleon. If my Definition of Air be allowed, so much of the Paper is most certainly *transformed* into Air. The Parts are gone, we are sure, by Deficiency of their Weight. They could not be annihilated ; they could not rise, and fly away without a repelling Force to carry them off, and they are too fine to be perceived by the Eye, after they are got beyond the small Extent of the Flame. Thus, the Candle itself by Degrees is wasted, and at length is *transmuted* from a Substance of heavy, co-hesive, palpable Wax, to that of a light, elastic, and impalpable Body of Air.

Euphros. By this Example I see what wonderful Changes are made in the Nature of Things by the Action of Heat and Fire ; and one Thing I cannot help taking Notice of is, *viz.* that all those Parts of Bodies which in this Way become Air must first put on the Appearance of Fire itself, or pass thro' the intermediate State of Flame ; so that, properly speaking, the same Body was one Moment *Paper*, the 2d Moment *Fire*, and a 3d *Air* ; all which appear to be very different States for the same Sort of Matter to subsist in, in so very short a Time.

Cleon. And yet, as wonderful as such Operations of Nature must appear, when rightly considered, we see how little Effect they have on the unthinking Part of Mankind. They see their Wood and Coal every Day in this Manner converted into Air, without entertaining any Thought or Reflection on the Nature of the Thing, or being any otherwise affected than by its Heat.

Euphros. You cannot expect that People should go to philosophising on every Fire they want to warm themselves by. If they

they are warmed, and the Pot boils, no Matter what becomes of the Wood, when it is burnt.——But what mean these other Parts of your Apparatus,——The Phial——the Chalk——the Tube——the Quick silver, which I here see in a Kind of promising Situation?

Cleon. These are all destined for the Illustration of this important Point, the *Production of Air*. The first of these is the Glass-tube, which you observe with a Brass Cap at the End, and a small Hole in it; this Tube I shall fill with Water, and a small Quantity of *Aqua Fortis* to make it acid; then this Piece of Chalk being put into the Mixture, a Fermentation will ensue, by which the Particles of Chalk will be separated, and turned into Air; for Fermentation is another grand Operation in Nature, by which the Parts of Bodies undergo the greatest Variety of Transmutations, and by which many of their Parts are constantly changed into Air. But, that you may see the Effect of this Experiment in the most convincing Manner, I shall first fill the Tube with Water; and then, tho' I place my Thumb on the Top of it, you observe no Water runs through the Hole at the Bottom.

Euphras. I do, but since there is a Hole open, pray, why does not the Water descend by its Weight?

Cleon. Because the Air, being a fluid Body, presses upwards as well as downwards, and the Pressure upwards against the Water in that Hole is much greater than the Pressure downwards, and therefore will prevent its running out.——But see, I take my Thumb away, and then the Water descends in a Stream thro' the Hole.——I place my Thumb on again, and it stops.——I remove my Thumb, and the Water runs out.

Euphras. There is something odd in this Appearance, and yet, I believe, I see the Reason of it; for when the Tube is open on the Top, and the Weight of the Air lies upon the Water, and the Weight of both together downwards being greater than the Pressure of the Air upwards, must necessarily make the Water run out; and of Course it must stop again, when the Tube is closed on the Top.

Cleon. I see nothing will escape your Sagacity; and now you are prepared to see the Effect of Fermentation.——You see, I fill the Tube with the acid Mixture——I put in the Piece of

of Chalk——and immediately I put in the Cork, so that you now see the whole Tube filled with the Fluid only, without any Air at the Top.——But behold! Numberless Bubbles of Air arise from the Chalk in a constant Succession to the Top of the Fluid: The Consequence of this is, that the Fluid must be pressed by this new Air, and when its Spring becomes greater than that of the common Air on the Outside, it will drive the Fluid out of the Tube.——Thus you see it keeps continually dropping from the Hole.

Euphros. 'Tis with great Pleasure I observe what you say——What prodigious Quantities of Air do I see constantly arising from the Chalk!——It is a perfect Evaporation of Air.——The longer it continues the greater is the Fermentation, and the faster the Water drops from the Tube——It has now expelled more than one Half, and will soon drive the Whole of it out.—But, pray, *Cleonicus*, whence comes this Air from the Chalk? It is not that which is contained in the Pores of the Chalk?

Cleon. No, my *Euphrosyne*, you must take Care of the common Mistake. Most People, as well as you, are apt to think, that it is owing to the Dilatation of natural Air contained in the Pores of Chalk; but they are greatly mistaken; for such Air cannot be dilated, or made to possess a larger Space than what it naturally does, unless it be by Heat, or taking off the Weight of the circumambient Air; for the Fermentation produces no Heat in the Chalk, and therefore the Air, contained in the Pores, cannot be dislodged upon that Account. Nor is the Pressure of the Air lessened upon the Chalk, but really increased by the additional Weight of Water; therefore, it is impossible upon either of these Accounts, or any other, to conceive, that this Air, which we see arise from the Chalk, fill the Tube, and drive out the Water, should any how proceed from the Air in the Pores of the Chalk.

Euphros. You have said enough to convince me that it cannot; and if it be not from that Air, it must be from the Chalk itself of Course; and I suppose, by what you have hitherto shewn me, I may venture to say, that the very Particles of the Chalk itself are changed into Air by Fermentation.

Cleon. That is the very Case: The Chalk becomes Air, or a Substance altogether invisible to the Eye. It has an elastic Force,

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Force, and that superior to the Elasticity of common Air, as is demonstrable by forcing the Water out of the Tube, which was at first kept in by the common Spring of the Air.

Euphros. But what means this Tube with a Bladder tied on to the End?

Cleon. That is for an Experiment to the same Purpose.— You see here this Phial, into which I put the same acid Mixture and Chalk——and the same Effect you now observe ensues.—In the Brass Cap on the Top of the Phial, I screw on the Glass Tube with the empty Bladder on its End.— And now you readily perceive, that the new generated Air shews itself by entering the Bladder, and expanding it by Degrees.

Euphros. A curious Phænomenon this!——The Bladder begins gradually to unfold, and to increase in its Bulk from the increasing Quantity of Air arising from the Chalk. I apprehend, if we could wait to see this Experiment in its utmost Extent, the Bladder would be not only filled with Air, but at length would burst by the Force of its Spring.

Cleon. It certainly would, in the same Manner as it might by injecting the common Air with a Syringe; and therefore the Appearance and the Effects of this new generated Air being exactly the same with the common Air, there is no room to doubt, but that the Particles of Bodies are converted into the common Air that we breathe. But we have still other Experiments, which I shall shew you for the Sake of Variety, that will as evidently prove the Fact.

Euphros. I am fully satisfied and convinced of the Truth of this important Affair, but shall be glad to see it further illustrated by a Diversity of Experiments. Pray, what is your next?

Cleon. From this Phial, I screw off the Tube with the Bladder, and to the acid Mixture I pour in a Quantity of Quick-silver; then I take this Glass-Tube, 30 Inches long, and screw into the Phial with the lower Part descending a small Depth into the Mercury.—The Chalk now (as in the former Experiment) you see, yields a large Quantity of Air, which, as it cannot get out of the Phial, must press upon the Surface of the Quick-silver, and raise it up in the Tube——See, it begins to ascend.—

Euphros.

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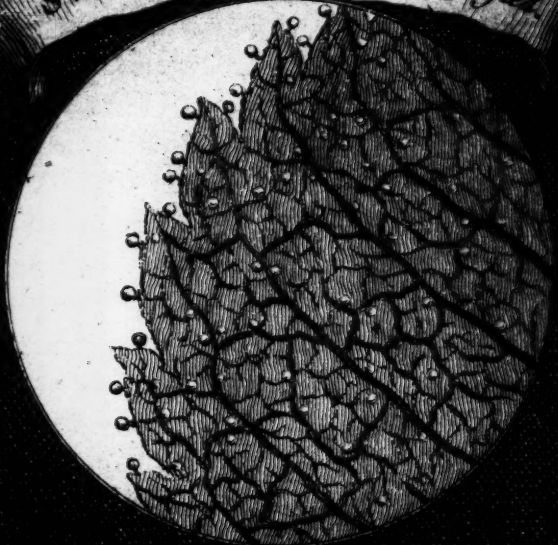
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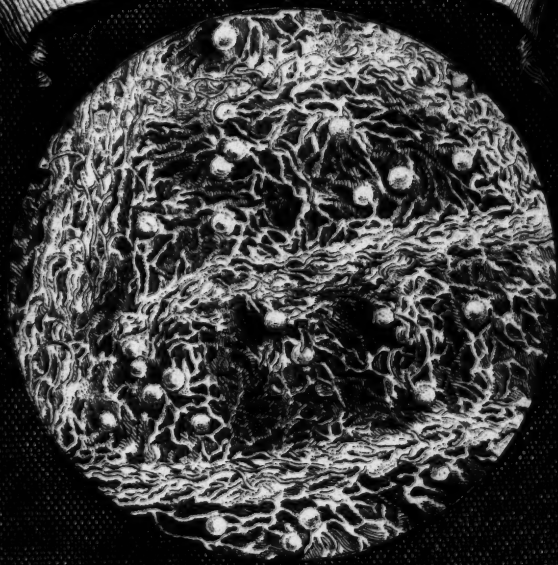
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Sweet Brier Leaf, Magnified.



Sage Leaf, Magnified.



Euphras. It evidently rises, and a delightful Sight it affords me. — It keeps gradually rising, which shews the constant

increased Spring of the Air in the Phial, arising from the Chalk.

— But, pray, *Cleonicus*, what would be the Case if this Experiment was to be tried for a long Time? To what Height would it raise the *Mercury* in the Tube?

Cleon. The Height of the *Mercury* would continue encreasing, till such Time as the Spring of the Air in the Phial (which is always equal to the Weight of the *Mercury* in the Tube) becomes so great, as to burst the Phial; and then, of course, the Experiment will be over.

Euphras. Why, you almost begin to make me afraid; for I see the *Mercury* is now high in the Tube. — Pray, unscrew the Tube, and let the Air out, lest I should see the Experiment concluded in the Manner you mention, which I would not chuse by any Means to do.

Cleon. I don't wonder, if your Timidity exceeds your Curiosity. No Body would care to be present at the bursting of a Glass. — But now observe, as I gently turn the Screw back, the Air goes out by small Degrees, and you see the Quick-silver subsiding in the Tube, which is no unpleasant Part of this Experiment.

Euphras. Every Part of this Experiment is really very curious, and I am convinced of the Truth of that Doctrine, which to me, at first, appeared not so very plain and demonstrable, and therefore should put you to no farther Trouble upon this Head, were it not, that you have yet one Experiment still remaining; which, I fancy, must be somewhat curious, by the Manner of it.

Cleon. 'Tis true, this is the *Experimentum Crucis*, as the Philosophers call it, or one perfectly decisive. I have before observed to you, that the Weight of any Body is always proportioned to the Number of Particles, or Quantity of Matter in it; from whence it follows, that, if the Quantity of Matter be diminished, the Weight of that Body will be lessened in the same Proportion; therefore, to shew that it is the real Substance, or common Matter of the Chalk, which is changed into Air by Fermentation, I have contrived the following Experiment. — I put into one Scale of the Balance, a small, cylindrical, glass

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Cup,

Cup, with a proper Quantity of the acid Mixture in it, ——— over which I place a Paper-cover : ——— On this Paper I place a Piece of Chalk, and then balance the Whole by Weights, put into the other Scale : ——— Lastly, I gently slip the Chalk into the Mixture under the Paper-cover, which prevents any of the Fluid flying off from the Cup in the Ebullition. ——— And now observe the Effect : As the Fermentation continues, the Particles of the Chalk change into Air, and fly away, and you observe that Scale is sensibly become lighter, and preponderated by the other. This plainly shews, that the Substance of the Chalk is constantly diminishing by the Diminution of its Weight ; and you may see at any Time how much of the Weight is deficient, by putting Grain-weights into the same Scale to restore the *Equilibrium*.

Euphros. This Experiment is certainly the Principal of all : It proves, beyond all Contradiction, the natural Production of Air from the solid Substances of Bodies ; and not only so, but in this Manner it will be easily found what Weight of Air a Body, of any given Weight will yield ; for I observe, that the Chalk keeps constantly diminishing, 'till at last it will all be dissolved.

Cleon. It is true ; but it will be too tedious to wait for that : The Event will shew, that one Half of the Chalk was turned into Air. But this depends on the Nature of the Chalk, and other Substances to be dissolved ; for some afford a great deal more, and others less, of this fine Matter. As it appears from these Experiments, that much Air is produced from Bodies, by the different Methods before-mentioned ; so there are many others, which equally prove, that the Quantity of Air is really lessened, consumed, or absorbed by Bodies. This is well known to be the Case of the Fumes of Sulphur, Fire, living Animals, &c. which are all found to lessen the Quantity of Air ; the Manner how this is done is not so easily understood as the Production of Air. But, as it is now Time to put an End to this Conversation, I shall recommend to your Perusal, at your leisure Hours, what Mr. *Boyle*, Dr. *Hales*, and several other Authors, have wrote upon this Subject, which will give you all the Satisfaction, in relation to this Matter, that you can desire.

DIALOGUE.

DIALOGUE III.

Of the Doctrine of WIND. Its Nature, Use,
and Causes.

Euphrosyne.

THE curious Subjects and Experiments of our last Conversation have engaged me to take the first Opportunity of troubling you again with my Enquiries. You have shewed me how, and in what Manner Air is produced; and I have been, since, reading the Authors you recommended, which have highly gratified my Curiosity, and greatly enlarged my Understanding; but several Things yet remain that I do not thoroughly comprehend; and concerning which I must beg your Solution of a few Queries relating to this surprizing Body of Air. I remember, *Cleonicus*, you some Time ago hinted to me, that the WIND was only the *Air in Motion*: This was too short an Account of so important a Subject, as the Doctrine of Wind, to satisfy me. I doubt not but you can give me a more full, and plain Idea of this Affair.

Cleon. The Subject of Wind, tho' nothing more, in a general Way of defining it, than *Air in Motion*; is, in itself, a most curious, important, and mysterious Subject, and has employed the most learned Pens of Philosophers to account for it, and the greatest poetical Geniusses to describe it. I need not mention to you the great Benefit, yea, the absolute Necessity it is of to all Mankind: Air, without Motion, I have already observed to you is as pernicious as stagnant Water, both equally deleterious, or poisonous to Animals. The dreadful Effects of a motionless Air, we find in close Apartments, Prisons, Ships, &c. as is sufficiently known by the happy Effects produced by Ventilators, and other Methods proposed for producing a Motion and Circulation of Air. We all find not only Health, but Pleasure from every gentle Breeze; and, with respect to the Ladies in particular, they have not a Fashion more founded on Philosophy than that of the FAN, for producing an artificial Wind, whenever they have Occasion.

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Euphros.

Euphros. I must confess, tho' I have been long used to this little Instrument, I never considered the Rationale of it before. I wish I could find as much Philosophy in many other female Trinkets. But now we are upon this Subject, I think I may as well observe to you, that a Pair of *Bellows* may be ranged under the same Class of useful Philosophical Instruments.

Cleon. You have rightly observed, my *Euphrosyne*; the Construction of the *Bellows* is truly philosophical, as are many other domestic Implements, which are little considered in that Light; for when the upper Part of the *Bellows* is lifted up, the Body of Air is lifted from the lower Part, and consequently, as you observe, a Hole is made in that Part, the Air will rush in, and fill the hollow Part of this Instrument with Wind; but when the Force of the Hand is applied to the upper Part, to depress it, it presses the internal Valve down upon the Hole, and prevents the Air from returning again that Way: The Body of Air within the *Bellows* is forced to make its Way thro' the narrow Hole of the Pipe, in a very rapid Manner, and, being directed to the Fire, produces that strong Blast which is necessary for begetting, and increasing that Element among the Fewel, in order to its burning briskly.

Euphros. This Implement is of much more Consequence than I ever imagined. I have, many a Time, supinely sat blowing the Fire, without ever considering how, and in what Manner, the Effect was produced; which now affords me no small Pleasure to understand: At the same Time I can discern the Reason of a Drawing-stove, by encreasing the Velocity, or Motion of the Air upon the Fire. And, indeed, one would think, our Cook-maids had got some Philosophy by Instinct; for when the Fire has been low, I have often observed them to set the Poker upright before the Grate, and used to wonder why they did it, 'till now I observe, it divides the Draught of Air, and makes it come in two Streams upon the Fire; it will, therefore, have a greater Force, and raise the Fire of Course. You'll excuse this short Digression ——— Pray, go on with your Subjects of more Importance.

Cleon. I like your Remarks so well, that I shall add another of that Kind to them; and that is, that the very Structure of a *Chimney* depends entirely upon the Motion of the Air; for the
Fire

Fire, rarifying the Air in the lower Part of the Chimney, makes it lighter than the Air in the Room, which, as it is heavier and lower, will drive up the lighter Air above the Fire, to the Top of the Chimney, and carry, by this Means, the Smoke along with it: And it is certain, if a Chimney was well made, according to the Rules of Philosophy, we should not be so often molested with that very disagreeable Phænomenon, a smoky Room. For it is certain, if there was a proper Draught of Air contrived over the Fire in the Chimney, it would always be sufficient to carry the Smoke of the Chimney upward, and overcome the Impulse of the Air on the Top of the Chimney. — But a smoky Chimney is only one bad Effect of Ignorance, and a general Contempt which the Vulgar shew to Philosophy.

Euphros. I am fully convinced, that we suffer many Inconveniencies of Life for want of being acquainted with the proper Means of removing them. — Now you talk of the Wind, it occurs to my Mind, that the Sails of the Wind-mill on yonder Hill, always stand a-slant to the Wind: I have thought to ask you the Reason of it several Times, but forgot it, therefore give me Leave to do it now.

Cleon. You could never have proposed it more opportunely, as the Wind-mill is a very considerable Instance of the great Benefit Mankind receives from the Motion of the Air. The Force of the Air in Motion, when considered, in a large Quantity, is very great upon the Surface of the Sails; if, therefore, those Sails were placed directly before the Wind the Force upon all the four Sails would be so great, as to blow down the Mill; and if the Sails were turned so as to be placed in the Direction of the Axis on which they are fixed, then the Wind, passing one Side and the other, would have no Effect upon them at all; but being placed obliquely, or Side-ways to the Wind, the desired Effect is produced, *i. e.* the Mill stands firm, and the Wind has yet Power enough on the Sails to give them a proper Motion, and to produce Force enough for turning the Mill-stones and grinding the Corn; which affords us that seasonable Supply of Flour and Bread in a Time of great Drought, when there is no Rain, and when our Springs, or Rivers fail us, or our Habitations are too far distant from them.

Euphros.

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Euphros. Yet, great as the Advantage of a Wind-mill is, I presume, it will bear no Comparison with the Construction and Use of a Ship.

Cleon. No otherwise than as small to great: For to say the Truth, a Ship is one of the most noble Machines, and the greatest Effect of Art that has relation to the Motion of Air: The Oceans themselves would be useless to us without the moving Air: The Ships might swim in them, but not sail without Wind: Our Goods are exported to foreign Countries, and the Riches of the *Indies* are waisted to us on the Gales of Wind that fill the Sails of our Shipping. In short, all that depends upon foreign Trade and Commerce is entirely owing to this beneficent Cause.

Euphros. I can easily see it would be endless to enumerate all the Advantages of the Wind. The next Question that I shall trouble you with is, Whether the Philosophers have ever yet been able to ascertain the true Cause, or Causes of the Wind.

Cleon. They have, to a considerable Degree: But we must distinguish Winds into three different Sorts; 1. The common, inconstant, or variable Winds. 2. The Whirl-winds, Tempests, and Hurricanes. 3. The constant, or stated Winds, usually called *Trade-winds*, and, in some Parts of the World, *Monsoons*; and the Reason of the last of these, I must first give you a short, and general Account of. You must know then, my *Euphrosyne*, that as the Earth revolves in its Axis from West to East, the middle Part of the Earth, and consequently the Atmosphere over it is very much heated by the Sun, by which Means it will become more rarified than other Parts remote from the *Equator*, or *Torrid Zone*; on this Account it will be also lighter; the heavier Air, therefore, from the polar Parts on either Side, being heavier, will be continually setting in towards the *Equator* to restore the Equilibrium of the Atmosphere, which constantly alter by the Rarification of the Sun. You will from hence easily learn, that a Motion will be produced in the Atmosphere, from North and South, towards the middle Parts of the Earth which would make to us, a constant *North Wind*, and to the People on the other Side of the *Equator* a constant *South Wind*, if there was nothing else intervening.

Euphros.

Euphros. So far I am capable of comprehending what you say: I wish what remains may not be more difficult than this.

Cleon. Indeed it will not; for you have only farther to consider, that the Parts under the Sun being mostly heated and rarified, and as the Earth turns Eastward, the Point of greatest Rarification in the Air will be constantly shifting towards the West; the western and eastern Air will, on both Sides, flow towards this Point; but as that on the West meets it, and the other on the East follows it, the Motion of the western Air will be lessened, and that of the eastern Air increased, and, therefore, that of the eastern Air will prevail against the Motion of the western Air, and so there will be a constant East-wind produced in Parts under, and near the *Equator*, if the Body of the Atmosphere was to be effected in no other Direction; but since the several Parts thereof are urged in two Directions, a Motion will result from thence between both, and consequently a *North-east* Wind be produced on the North-side of the *Equator*, and a *South-east* Wind in the southern Hemisphere; and these Currents of Air are what we really find in Nature, and are called by the Sailors the *Trade-winds*; and on your Maps and Globes you will generally find these Parts shaded, as far as they are sensible, which are nearly 30 Degrees on either Side of the *Equator*.

Euphros. I have often observed those shaded Parts, and the Arrows placed among them, all pointing in one Direction; which now I plainly see denote the Direction of the Wind; for they point N. E. in one Hemisphere, and S. E. in the other. But what is the Reason that in the *Indian* Ocean, and the *Chinese* Seas, and some other Parts, I observe those Arrows lye two by two in different Directions, or pointing towards contrary Parts, with the Names of the Calendar Months by them: Pray, what is the Purport of all this?

Cleon. These, Sister, are what the Sailors call the *Monsoons*; which for six Months of the Year blow one Way, and the other six the contrary; the Time being denoted by the Names of the Months affixed to them. In other Parts, they blow but three Months one Way, and three another; and the Direction of these Winds are not the same as that of the general *Trade-winds*, but some of them almost contrary to it, as you plainly see

see by the Position of the Darts : The Cause of which is generally this, that the Sun, during its Passage thro' the northern Signs, rarifies the northern Parts of the Atmosphere most, which is still farther increased by the great Reflection of the Solar Rays from the sandy Desarts of *Arabia*, and the *Indian Coast* in general ; all this Time the Currents of Air will come into those Seas almost in a South-west Direction. But when the Sun enters the southern Signs, it carries the Point of greatest Rarification on the other Side of the *Equator*, occasioning a contrary Current of Air, or the Wind to change its Course during the Winter Months of the Year. For such Sort of Reasons also you will observe the Arrows shew the Direction of the Winds, in various Directions, along the Coast of *Africa*, from the *Canary Islands* to the *Cape of Good-Hope*.

Euphros. I can see, from the Map, pretty well, the Reason of all that you have said ; but shall better understand this Subject when I have meditated more upon it. But, before I lay aside the Map, methinks, I see a Representation of some Thing like a Conflict of Winds, especially about the *Equator*, on the western Coast of *Africa*, and *South-America*.

Cleon. And so it really is, in Nature ; for over all those Parts, about the Times of the *Equinox*, when the Sun is in the *Equator*, the Motion of the two great Bodies of the Atmosphere clash and interfere, producing very great Storms, Tempests, and Hurricanes, attended with dreadful Rain, Thunder, Lightning, &c. of which you will find a more particular Account in Books of Voyages over those Parts, which would prove a very agreeable Amusement, were it not for the many affecting Scenes of Misery and Distress of the unhappy Seamen, who have, as it were, been made the Sport of these Winds, and often fall Victims to their Rage.

Euphros. You make me shudder almost at the Mention of them, which revives in my Mind the Remembrance of that poetical Description of a Storm and Shipwreck in *Virgil*, in the following pathetic Lines.

*Then Æolus hurl'd against the Mountain-side
His quiv'ring Spear, and all the God apply'd.*

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*The raging Winds run thro' the hollow Wound,
And dance aloft in Air, and skim along the Ground;
When, settling on the Sea, the Surges sweep,
Raise liquid Mountains, and disclose the Deep.
South, East, and West, with mix'd Confusion roar,
And roll the foaming Billows to the Shore,
The Cables crack, the Sailors fearful Cries
Ascend, and sable Night involves the Skies,
And Heav'n it self is ravish'd from our Eyes.*

*Loud Peals of Thunder from the Poles ensue;
Then flashing Fires the transient Light renew.
The Face of Things a frightful Image bears,
And present Death in various Forms appears.
Fierce Boreas drives against the flying Sails,
And rends the Sheets; the raging Billows rise,
And mount the tossing Vessel to the Skies.
Nor can the shiv'ring Oars sustain the Blow,
The Galley gives her Side, and turns her Prow;
While those a-stern descending down the Steep,
Thro' gaping Waves behold the boiling Deep.
Three Ships were hurry'd by the southern Blast,
And on the secret Shelves with Fury cast;
Three more fierce Eurys, in his angry Mood,
Dash'd on the Shallows of the moving Sand,
And in Mid-ocean left them moor'd a-land.
From Stem to Stern one was by Waves o'erborne;
The trembling Pilot, from the Rudder torn,
Was headlong hurl'd: The Ship thrice round was tost,
Then bulg'd at once, and in the Deep was lost;
And here and there above the Waves were seen
Arms, Pictures, precious Goods, and floating Men.
The stoutest Vessel to the Storm gave Way,
And suck'd thro' loosen'd Planks the rushing Sea.*

Cleon. Storms and Tempests are but too frequent at Land as well as Sea. Whatever can give a violent Shock to the Atmosphere, will produce what we call a high, or strong Wind; and it is easy to observe, that a Tempest at Land has some Connection, in its Causes, with those at Sea; for as the Equinoctial

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Suns

Suns produce generally the greatest Commotions in the Atmosphere about the Equator; so we sensibly find them extending to our Latitude, and produce that boisterous, and turbulent Weather we generally experience about *March and September*. Besides these general Causes of our variable Winds, there are, doubtless, many particular ones which I cannot undertake to specify; for whatever can alter the Equipoise of the Atmosphere, will always produce Motion, or Wind, in the Air. But one great Cause of Wind may be supposed to arise from the great Influence the Moon has upon the Atmosphere, producing *Tides of Air*, as far superior to those of the Ocean, as the Air is lighter, and more free to move than Water. Those constant Alternations in the Height of the Atmosphere must necessarily induce a Motion through the whole Body of it, greater or less in different Parts; which, with many other concurring Causes, will variously agitate the Body of Air, and produce those common Winds so necessary to the Well-being of the whole present Frame of Nature.

DIALOGUE IV.

Of the Nature and Generation of METEORS.

Euphrosyne.

I Think I know enough of the Philosophy of Winds from your last Conversation, and what I have read since upon that Subject. I have perused Dr. *Halley's* Account in particular, which gives me the highest Satisfaction. But the Season is now drawing near, which will present us with a Scene of those common Phænomena, which you Philosophers call by the Name of *Meteors*; but, common as they are, I have met with so little, relative to an Explication of their Causes, either in common Converse, or in my general Course of Reading, that I know as yet but little of that Affair, and therefore I must now desire your Assistance for my understanding it in this Respect.

Cleon.

Cleon. 'Till very lately, Philosophy has not been the Subject of Conversation, and it is but rarely so now. Politics, and pleasurable Subjects ingross the general Attention of Mankind, and trivial Romances take up but too much of our Reading-leisure; our animal Sensations must be first gratified at all Events: Dress, and Equipage are of too high a Consequence to be neglected; and, if after all, we can find a little Time for mental Disquisitions, and Researches, Philosophy is sometimes permitted to bring them up in the Rear. We hear the Winds blow, we see the Vapours rise, and observe the Clouds driven about in the Air; the descending Showers of Rain often alarm us; Frosts and Snow make us shudder at the Change of Seasons, and the awful Phænomena of Thunder and Lightning seldom fail to raise our Admiration of the Wonders of Omnipotent Power in the upper Regions of the Air; but after they cease, and the Air becomes serene and calm, our Amazement ceases, and we become so far becalmed in our own Minds as scarcely to be disturbed a Moment about the Cause or Reason of such wonderful Appearances; as if it was only the Philosophers Business to be acquainted with the Causes of Natural Things, or, that every reasonable Man was not concerned to regard *the Works of the Lord, or consider the Operations of his Hands*. But these Reflections avail but little with the inconsiderate Part of Mankind; your Emulation is of the noblest Sort; you not only see and hear in the Animal Way, but rationally enquire into the Reason and Causes of those Phænomena which strike the Senses, of which those we call *Meteors* are the principal.

Euphros. Pray, spend no more Time in complimenting me; but tell me how I am to proceed in my Enquiries, or take your own Method to explain the several Subjects of our present Conversation; for a natural Method is a great Matter in such Cases.

Cleon. 'Tis true, Method is a principal Thing, all the Logicians agree; and therefore, in the first Place, the VAPOURS arising from the Earth by the Heat of the Sun, and the internal Warmth of the Earth, are the Subjects of our present Enquiry.

Euphros. You have already explained to me, in a great Measure, the physical Cause of the Ascent of Vapours in a former Conference; which, if I remember right, you said consisted in a repulsive Force between the Parts of Matter, by which, such

as were separated from the Surfaces of humid and other Kind of Bodies, were repelled, and driven up into the Air in the Form of Vapours.

Cleon. Your Memory renders you an excellent Pupil. That is certainly the first Step Nature takes in forming Vapours. And now we must consider the second, *viz.* The Reason of their rising into the Air to the Height they do. This is owing to the Vapour being lighter, in an equal Bulk, than the Air; and you will find no Difficulty in conceiving, that a lighter Body must necessarily rise in a heavier one; as a Piece of Cork, placed at the Bottom of a Vessel of Water, and there left to itself, will rise to the Top immediately, by Reason of the superior Weight and Density of the Water: But this, however, I shall explain to you more fully, when we come to the Principles of *Hydrostatics*.

Euphros. If the Vapour be Bulk for Bulk lighter than Air, I know it must necessarily rise in it, and I see it every Day confirmed by natural Experience; but I should not have thought thus, since I can so plainly see the Vapour, but the Air is so fine that I cannot see it at all, and therefore I should have thought that had been the lightest.

Cleon. You think as most People do; but you see from hence, how necessary it is to have our vulgar Thoughts corrected, and to have the Art of Thinking, and Reasoning right. Philosophy is natural Logic; by it we are convinced, that the respective Weights of Bodies do not depend on their Visibility. The Fish, in the Element of Water, see no more the Parts of Water than we do those of Air; but the Buoy, and other Objects floating on the Surface, are still the Objects of their Sight, in the same Manner as Vapours and Clouds are of ours.

Euphros. Well, I am almost ashamed of my Ignorance. But you know, *Cleonicus*, every one must have Time to learn. But since the Vapours being lighter must rise in the Air, why do they not, for ever keep rising, and so, by Degrees, get out of our Sight, and be dissipated quite away?

Cleon. To understand the Reason of this, you will recollect, that I told you the Density and Weight of the Air was every where variable, being greatest of all at the Surface of the Earth, and decreasing gradually, upwards; therefore, tho' the Air near the

the Earth be heavier than the Vapour; yet, as its Gravity continually decreases, it will, at length, become lighter than Vapour in its upper Parts, and in one particular Region between, it will be equally heavy with the Vapours themselves; whence it must follow, that the Vapours will rise from the Surface of the Earth to this Part of the Atmosphere; and since all the Air above is lighter, they cannot possibly rise higher; here therefore they will remain in Equilibrio with the Air, and appear under the Form, and take upon them the Denomination of CLOUDS. The Clouds, thus produced, are seldom quiescent, or without Motion, more or less. As the Air becomes variously agitated, the Clouds are carried about and driven to and fro therein.

Euphros. I seem, by what you have said, to have a tolerable Notion of the Matter: But, pray, whence comes it to pass, that the Clouds, in those upper Regions of the Air, have those very different Aspects and Positions, sometimes rising high in the Air, ranged in Form of aerial Mountains, and variegated with beautiful Colours of Light; at other Times, they, seemingly, approach much nearer to us, and appear with horrid Aspects, black and lowering.

Cleon. The general Cause of these Appearances arises from the different Weight of the Air at different Times; were the Weight of the Air to continue always the same, the Clouds would always be seen at the same Height; but many Causes concurring to alter the Gravity of the Air, over any particular Place, if it becomes greater, the Clouds will rise higher, and one Series of Clouds above another, reflecting the Light of the Sun above, or below the Horizon, which paints the delightful Views, and Landships in the Air you just now mentioned; at other Times, when the Gravity of the Air is lessened, the Clouds descend of Course, and, running together, mix, and condense into a large, and more opaque Body; in such Cases they generally fill the visible Atmosphere, eclipse the Sun from our Sight, shut out the Light of the superior Air, and make all dark, and gloomy about us below.

Euphros. Pray, *Cleonicus*, will it be an impertinent Question to ask, what may be the *Height of the Clouds*?

Cleon. Not in the least; so far from it, that it is commonly observed, People are more inquisitive about the Height of the Clouds, than any other Circumstance belonging to them; and it is not

to

to be wondered at ; for, perhaps, there is not a more curious Problem in Philosophy than to determine the Height of the Clouds.

Euphros. Do you think I could understand any thing of the Method of doing it ?

Cleon. Yes ; you will not only understand it, but may easily practise it too.

Euphros. Indeed ! Then I should think myself Somebody, if I were able to measure the Height of the Clouds. But, pray, how must I proceed in that Affair ?

Cleon. It is done by means of an *half-second Pendulum*, and a Flash of Lightening. —

Euphros. Of Lightening, do you say ! Dear me, I am so terrified at the Appearance of Lightening, that I can scarce shew my Face to the Clouds, how then can I measure the Height of them ?

Cleon. You are like the People going to *Italy*, who would fain get thither, without ascending the *Alps*. — If you would be a Philosopher, you must have Courage enough to face the Artillery of a Cloud. However, to be serious, I am far from insinuating, that there is no Danger from a Flash of Lightening ; we have but too many affecting Instances of the Contrary ; but as, on the one Hand, there is no Occasion to be fool-hardy in gazing on the opening Cloud ; so, on the other, it would discover too great a Pusillanimity to shut our Eyes against every Flash of Lightening.

Euphros. Well, then, you may trust me for Courage in this Respect ; but what Skill does it require to manage the *Pendulum* ?

Cleon. Little Skill, Time, or Labour is here required. The Method is thus : — You see this Pendulum is nothing more than a Ball, suspended by this String, which when I hang it upon a Pin, it will move, or vibrate about it, as you here see. — It is made just 9 Inches and eight Tenths of an Inch long, that it may vibrate in *half a Second* of Time : The Pendulum, thus suspended, you take in your Hand, and hold it on one Side, ready to let go, when you see the Flash, which you are supposed to be waiting for. — The Moment it lightens, you let go the Pendulum, and then tell the Number of Vibrations that happen

be-

between that Time and the Moment you hear the Stroke of Thunder.——And thus you have measured the Time which the Sound takes up in coming from the Cloud to the Ear.

Euphros. All this is nothing more than what I can easily perform. But how am I, from thence, to understand the Distance, or Height of the Cloud?

Cleon. Very easily; for it is well known, from a Multitude of Experiments that have been made, that the Velocity of Sound is uniformly at the Rate of 1142 Feet per Second; therefore, in Half a Second it moves 571 Feet, and consequently, if you multiply this Number 571, by the Number of Half-seconds, which are made between the Flash and the Stroke, that will express the Number of Feet in the *Height* of the Cloud, if it be nearly over your Head; or its *Distance* from you in any other Situation; and in this Manner you will continue measuring the Distance of the Cloud all the Time it is passing from the Zenith to the Horizon; and, by that Means, become acquainted with the Extent of the visible Hemisphere of the Clouds.

Euphros. Such a Practice as this will afford me as much Pleasure as such Kind of Weather will admit of. I intend to take the first Opportunity for this Purpose; but I shall take care to have you present, as well for Company as Assistance.——But, for the present, I must proceed in my Queries: Please, therefore, to let me know, in the next Place, what are the general Causes of *Rain, Hail, Snow, Frosts, &c.*

Cleon. In these Particulars I will give you all the Satisfaction I can. The general Cause of Rain is, as I said before, the Alteration of the Weight of the Air; by which Means, the Clouds descend, intermix and embody together, and thereby become much heavier; the Weight now forcing the aqueous Particles together, they attract each other, in Consequence of which, the Cloud becomes liquified, or dissolved into Water, much after the same Manner as you see a heated Steam or Vapour become condensed, or run into Drops against any cold Surface. The Water of the Cloud, as fast as it is produced by this Coalescence, and Condensation, being heavier than the Air, must necessarily distil through it, and descend in Drops of Rain; and thus from the Basis, or lower Part of the Cloud, proceed those Showers
which

which the Bounty of Providence bestows upon every Part of the Earth, as there is Occasion, or Necessity for them.

Euphras. This seems to be a very natural and genuine Account of Rain; but as it proceeds from natural and seemingly accidental Causes, I should wonder how it comes to pass, that we have not constantly too much, or too little Rain, for any one Place; as Chance alone can never be supposed to steer clear of Extremes; but I observe, you mentioned the *Hand of Providence* in the Case, which gives an easy Solution of this, otherwise, wonderful Event.

Cleon. There is no other Way of accounting for such an Oeconomy in the Clouds. Such a just and necessary Distillation, and Distribution of Waters, from the grand Alembic of the Atmosphere could never proceed but from the Superintendence, Wisdom, and Direction, of that omnipotent Chemist, in whose Hands are all the secondary Powers of Nature, to vary their Operations as he sees consistent with the general Good of Mankind.

Euphras. I am satisfied of the Truth of what you have observed; but may we not reckon the Winds another general Cause of Rain, by driving the Clouds together, and forcing them to coalesce, condense, and become heavier, and therefore to fall in Rain?

Cleon. Most assuredly: You have expressed this Matter as well as any Philosopher could have done. Those Winds that blow from the Ocean, as the *South* and *West-winds*, bring large Recruits of Vapours to the Clouds, and therefore are more inclined to produce Rain than others which come off the Land, as the *North* and *North-East-winds*, which generally disperse the Vapours, and blow the Clouds away; as is thus elegantly expressed by *Ovid*.

*Fierce Boreas flies,
To puff away the Clouds, and purge the Skies:
Serenely while he blows, the Vapours driv'n,
Discover Heav'n to Earth, and Earth to Heav'n.*

DRYD. OVID.

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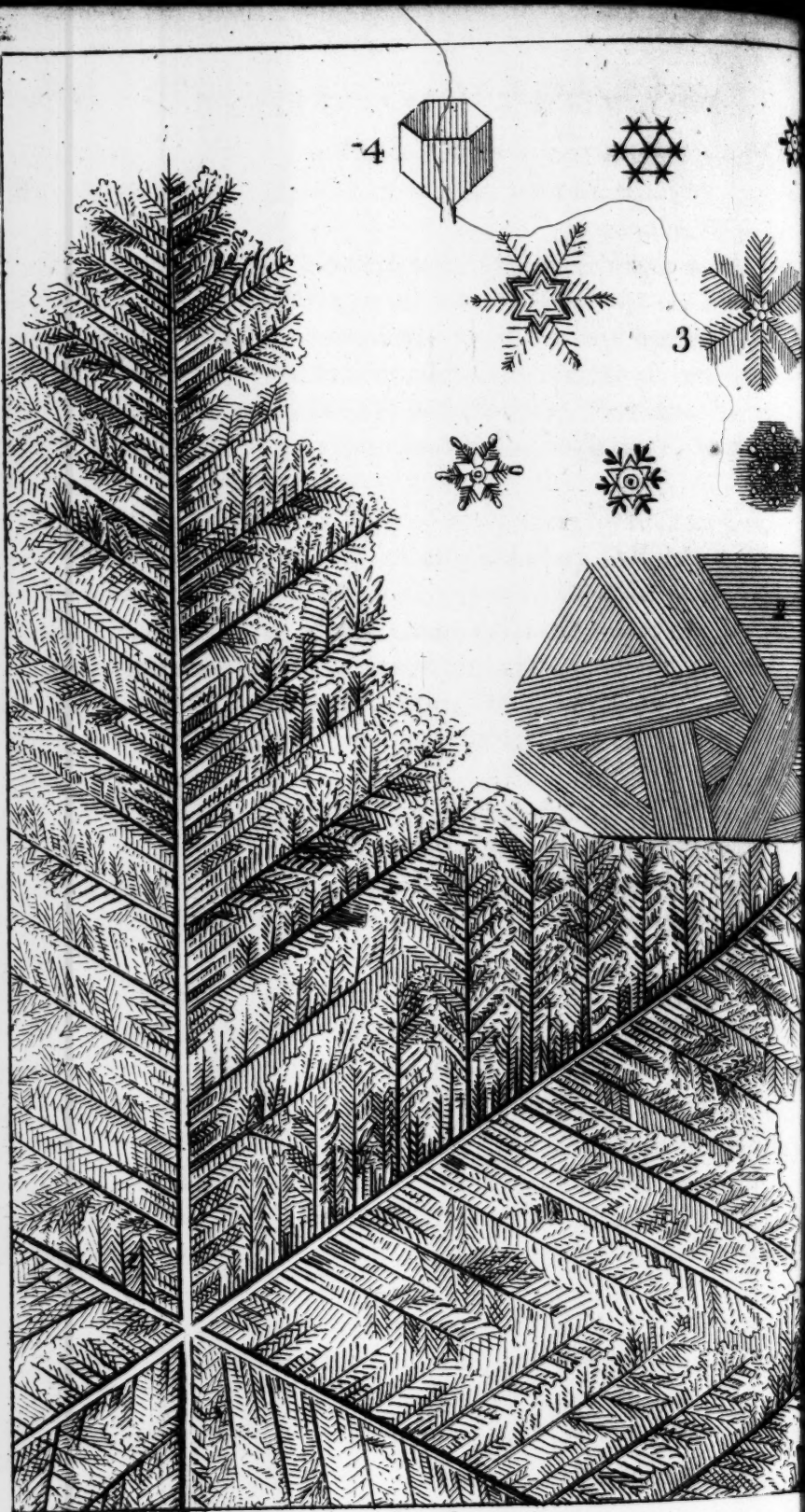
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The
VEGETABLE CRYSTALLIZATION
of Water in
ICE, SNOW, FROST, &c.

The same Poet very philosophically introduces the South-wind, as bringing Fogs, Mists, and Rain upon the Earth.

*The South-wind Night and Horror brings,
And Fogs are shaken from his flaggy Wings.
From his divided Beard two Streams he pours,
His Head and rheumy Eyes distil in Show'rs:
With Rain his Robe and heavy Mantle flow,
And lazy Mists are low'ring on his Brow.*

DRYD. OVID,

Euphros. You have pretty well satisfied me, as to Wind and Rain; but how do you account for Fogs and Mists, which oftentimes so far obscure the Body of the Atmosphere, that we can scarcely see any Thing at a Distance from us?

Cleon. Every Sort of Vapour of this Kind, that goes under the Name of Fogs and Mists, is only a denser Kind of Vapour, which is too heavy to be immediately raised up into the Air. The Condensation of this Vapour is either owing to a greater Degree of Warmth in the Surface of the Earth and Water, which throws it off in a greater Proportion than common, and faster than it can rise through the Atmosphere; or else, to the Want of a sufficient Degree of Heat in the Atmosphere to attenuate those Vapours, and increase their Elasticity, and consequently their Rarity: For Want of these Qualities they are detained in the lower Part of the Atmosphere in large and opaque Particles, visible themselves to the Eye; but preventing Vision of other Objects through them.

Euphros. The Case then, I conceive, is somewhat analogous to One's Breath in a cold Morning, which then, I can plainly perceive; whereas, in a warmer Air, the Particles of One's Breath become invisible, and therefore, insensibly fly off, and mix with the Air. In like Manner, as I have often seen, after a foggy Morning, and the Sun has ascended high enough to warm the Atmosphere with its Beams, the Mist, or Fog has been, by Degrees, dissolved, and dispelled in the Form of Clouds; or, at other Times, totally vanished away. Agreeable to which, I remember the following Verses of *Milton*.

*Ye Mists and Exhalations, that now rise,
From Hill or steamy Lake, dusky and grey,
'Till the Sun paint your fleecy Skirts with Gold:
Either to deck with Clouds th' uncolour'd Sky,
Or wet the thirsty Earth with falling Show'rs.*

MILTON's Paradise Lost.

You have satisfied my Curiosity with regard to *Fogs* and *Mists*; but how am I to understand the Reason of that Phænomenon which we usually call a *Hoar-Frost*? I know it proceeds from Cold; but should be glad to know the Manner how.

Cleon. Cold is only a comparative Term, and signifies nothing more than a less Degree of Heat, which we usually call a moderate Warmth. Now it is well known, that many Bodies will liquify with one Degree of Heat, and become fixed with another: This is the Case of all *Metals, Salts, Oils, Water, &c.* With one Degree of Warmth, Water will appear in a fluid State; with a less Degree, the Particles will be found to be fixed, congealed, (or as we usually term it) frozen. Thus the Vapours, in a warm Air, are in a fluid State, and when condensed by the Coldness of the Evening, and descend, they adhere to the Piles of Grass in the liquid Form of pearly Drops, which, in that Case, we commonly call *DEW*; but these very Particles in a colder Air will be fixed, and while they are floating in the Air, they make what is called a *Rimy-Fog*, or *frozen Mist*. When these Particles descend, they fall upon the Grass, and the Twigs of Shrubs and Trees, and make a beautiful Incrustation, which is called a *Hoar*, or *White-Frost*, in Contradistinction to another Sort, which is called the *Black-Frost*, only because it does not appear white; and this *Black-Frost* differs from the other in nothing more than this, that it is not attended with a Mist or Fog.

Euphros. The Account you have given of *freezing*, in the Parts of Water, seems, to me, very natural; but how am I to understand the Manner of those Particles becoming *fixed*, which I think you have not sufficiently explained?

Cleon. It is certain, from Experience, that Fluidity in the Parts of most Bodies is promoted (I will not say occasioned) by Heat; and Fixity (or freezing in Water) is the Effect of Cold,

or

or a less Degree of Heat: But to pretend to describe the Mode of Action, or Process of Nature in this Respect, I will not pretend to; for what I should naturally think was likely to account for freezing is inconsistent with another Phænomenon of that Affair, viz. that all these Bodies, in a fixed State, have a larger Bulk than in a fluid one. This Water, set to freezing in a cylindric Vessel, will be congealed into a larger Bulk of Ice, which is nothing but *Water fixed*. On the other Hand, a fixed Metal, as *Lead, Tin, &c.* when melted, or liquified, runs into a lesser Space, or becomes of a less Bulk. These Appearances make it somewhat difficult to account for the Nature of freezing, or Congealation, so perfectly as one might wish; and therefore you will excuse my saying any Thing more than I know upon this Subject.

Euphras. Very readily, dear *Cleonicus*; it is certainly overdoing the Thing, to load any Theory with Conjectures; nor was I ever fond of any Hypothetical Reasoning, tho' I should prefer your Opinion, if I chose to be instructed in that superficial Way. — I am glad you have put me into so good a Way of thinking about this cold, but very curious Subject, which is so elegantly described by the late ingenious Dr. *Broome*, in the following Lines.

*When stormy Winter, from the frozen North,
Borne on his icy Chariot, issues forth,
The blasted Groves their verdant Pride resign,
And Waters, harden'd into Crystal, shine:
Sharp blows the Rigour of the piercing Winds,
And the broad Flood, as with a Breast-plate, binds;
Ev'n the proud Seas forget in Tides to roll,
Beneath the freezing of the northern Pole;
There Waves on Waves in solid Mountains rise,
And Alps of Ice invade the wond'ring Skies;
But if warm Winds a warmer Air restore,
And softer Breezes bring a genial Show'r,
The genial Show'r revives the chearful Plain,
And the huge Hills flow down into the Main.*

BROOME.

Cleon. The Doctor has expressed the Thing very elegantly; and, at your Leisure, you may consult Mr. *Thompson's* poetical Philosophy at large, on this Head, in his *Winter Seasons*; and the next Opportunity that offers I shall take to explain the Nature of other Meteors to you,

DIALOGUE V.

*The Nature and Generation of METEORS, continued,
Of SNOW, HAIL, LIGHTENING, THUNDER,
Aurora Borealis, &c.*

Euphrosyne.

SINCE our last Interview, the Weather, having been very cold, gave me an Opportunity of observing, more particularly, the various Phænomena of freezing, which you then explained to me; and among other Things, the Fleaks of Snow very much entertained me as they fell on the Leads before the Window. These I viewed with a magnifying Glass, and thought I perceived something very beautiful and regular in their Form. Pray, what Account do the Philosophers give of this striking Phænomenon we call SNOW?

Cleon. It is a Subject every Way worthy of your Speculation, and one of the most curious Productions of Nature. This has been already intimated to you by your Glass, and will be farther evident, when you view them thro' a larger Magnifier. The Philosophy of *Snow*, in short, is this. — The Particles of all Salts have a natural Disposition to run together, and constitute some particular, or special Form: and as those Particles are originally, and, in themselves, transparent, and clear as Glass, or Crystal, this natural Action of shooting into those peculiar Forms is what they call CRYSTALIZATION; and the Particles so combined and configurated are called the Crystals of such and such Salts, or Metals. On this Head we shall be much larger hereafter; it is sufficient, at present, that you consider Water as an insipid, fluid Salt; and that the upper Region

of the Air, where the Parts of nitrous Salts abound, this Disposition to freezing or Congealation, is very great in the Winter-seasons, when the Atmosphere is much less heated by the Sun's Rays: The *Aqueous Particles*, therefore, mixing with *Nitre*, immediately shoot into *Crytals*, and form the original Parts of *Snow*, whose Figure is truly wonderful, as being strictly mathematical; for from one Point, as a Center, they irradiate into six different, but very beautiful Parts, more or less connected, and variegated with an Appearance of a vegetable Form, or Nature. These snowy *Crytals*, being of this hexagonal and ramous Form, makes them apt to hitch into, and hang upon one another, 'till they make a Body too heavy to be supported by the Air, and then they descend in the Form of *Flakes of Snow*, which are smaller or larger, according to the Degree of Cold which forms them: And if you examine one of those *Flakes of Snow* by your Glass, you will plainly see the Truth of what I have now mentioned, viz. that they are only a Collection of a great Number of those original, regular *Crytals*. These being of a large Bulk, in respect of their Weight, make them descend with a gentle and irregular Motion thro' the Air; so that a Shower of *Snow*, tho' common with us, and therefore not so much regarded, is, in itself, a most beautiful Thing, and is looked upon by the Natives of southern Climes, on their Arrival here, as the most extraordinary and amazing Phænomenon of Nature.

Euphros. What you now observe, I know to be Fact; having been in Company with a Creole Lady, just arrived in *England* from *Jamaica*, a Country, where *Snow* and *Ice* have been heard of, but were never seen; I shall never forget how it affected her Mind, when she first saw this new Wonder of descending *Snow*. It was a considerable Time before she could speak a Word, standing, as it were, in silent Amazement for several Minutes; nor could she be prevailed upon to turn her Eyes from this unusual Sight, for more than half an Hour, 'till her Attention to this Phænomenon had greatly impaired her Health by taking a very great Cold, and other Illness that followed: ——— And when she was shewn a Piece of *Ice*, she could not conceive how it was possible for *Water* to be transformed into such wet, and slippery Glass, as she called it. One may see, by these Instances, how little

little Mankind are apt to be affected by the most wonderful Operations of Nature, when they become the common Subject of our Senses. — But, pray, *Cleonicus*, have you any Experiments by which you can illustrate this Doctrine of Snow?

Cleon. Yes; and a very curious one, which is thus: — I take this tall Phial of *Aqua-fortis*, and set it by the Fire, 'till it is warm; — then I put in it Filings of pure Silver; a few at a Time, and you see, they presently dissolve with a brisk Ebullition: — At length, you see the Silver dissolve very slowly, which is a Sign, that the Fluid has taken up as much as is necessary for our Purpose.

Euphros. All this I observe with the greatest Pleasure. But, pray, let me ask you one Thing, by the Way: What is that Copper-coloured Fume that arises at the Mouth of the Phial, every Time you put in the Silver?

Cleon. That is a Sort of *Arsenic*, evaporating as the Silver dissolves, and it is the strongest Poison in Nature; but of this I shall give a more particular Account, when we speak of the Nature of Metals. — I wipe the Phial clean, and place this Solution of Silver in a cold Place in the Window; — it soon becomes clear and transparent; — as it cools, the Silver Particles, like those of Water, will shoot into Crystals; — and several of these running together will form a Flake of Silver Snow, and visibly descend, thro' the Fluid, to the Bottom of the Phial. It is only your waiting a little while, and you will perceive it very evidently.

Euphros. I shall wait with Pleasure for this extraordinary Sight. — The Solution is quite clear, and almost cold. — If I am not mistaken, I think I saw some Thing like a Flake descend: — I see two, three, and more, very plainly descend, one after another: — They now descend so very fast, as perfectly to represent a *Shower of Silver Snow*. — Those Flakes of Snow lie one upon another at the Bottom of the Phial like real Snow upon the Ground. — I think this one of the finest Experiments I ever saw with my Eyes!

Cleon. It is certainly so; and if you take out your Glass, and view those Crystals, as they lie at the Bottom, you will observe the same Geometrical Form in them, as you did in *Aqueous Snow*.

Snow. I could contrive this Experiment to be still much more sensible, but it would take up too much of our Time at present.

Euphros. What you have shewn me is very sufficient: The natural and artificial Snow have so exact a Resemblance, that my Glass will not discover any Difference. I see the same regular Ramifications in one as in the other; and, pray, how long will this Silver Snow remain at the Bottom without dissolving?

Cleon. 'Till the Weather becomes warmer. For while it remains cold, these Crystals will not be resolved, even tho' you pour off the fluid Part, and keep them dry in the Phial.

Euphros. Well, it is all very wonderful. — And when I consider the Earth covered with Snow, and the Houses cloathed therewith, and the Trees bending under the Weight of it, the bleak Scene reminds me of another Description of Dr. *Broome*, which is very poetical, in these Lines.

*He from ærial Treasures downwards pours,
Sheets of unfully'd Snow in lucid Show'rs;
Flake after Flake, thro' Air, thick-wav'ring flies,
'Till one vast shining Waste all Nature lies.
Then the proud Hills a Virgin Whiteness shed;
A dazzling Brightness glitters from the Mead:
The hoary Trees reflect a silver Show,
And Groves beneath the lovely Burden bow.*

BROOME.

Cleon. To this I may add another Description of the same Nature, from *Homer*, translated by Mr. *Pope*, as follows.

*As when high Jove his sharp Artillery forms,
And opes his cloudy Magazine of Storms;
In Winter's bleak uncomfortable Rain,
A snowy Inundation hides the Plain:
He stills the Winds, and bids the Skies to sleep,
Then pours the silent Tempest, thick and deep:
And first the Mountain Tops are cover'd o'er;
Then the green Fields, and then the sandy Shore:*

Pent

292 *The young GENTLEMAN*

*Bent with the Weight the nodding Woods are seen,
And one bright Waste hides all the Works of Men:
The circling Seas alone absorbing all,
Drink the dissolving Fleeces as they fall.*

POPE's Iliad.

Besides a good deal more, of this Kind, which you will find in *Thompson's Seasons*, and other Pieces of philosophical Poetry.

Euphros. I fear I have almost tired you on the Subject of *Snow*; but you are yet to acquaint me with the Nature of *HAIL*. I presume I shall not be so tedious to you on that Head.

Cleon. The Consideration of *Hail* may be dispatched in a few Words. For you are to consider, that it seldom or ever *bails* but when the Air is heavy, and the Vapours ascend to a great Height in it, which is mostly the Case in Summer-time, when Storms and Hail are much more frequent than in Winter. In the higher Regions of the Air, the Cold is much more intense, and therefore, it is presumed, a much greater Quantity of Nitre is there to be found; this causes a more immediate and stronger Congealation of the *aqueous Particles*, and binds them firmly into a Body of Ice of various Magnitudes, or Sizes, according to the Degrees of Cold. These becoming considerably heavy descend from those Heights with great Rapidity, in the Form of a *Shower of Hail*, and when the Hail-stones are very large, they strike with a very great Force, as we very often experience to our Cost.

Euphros. This I well know; as it was not long before your Return from College, that all our Windows were broke by an eastern Storm of Hail; and I remember one of those Hail-stones were more than half an Inch in Diameter; and further I observed, those large Hail-stones were not near a round Figure, but oblong, and flattish. Pray, how do you account for the Form and Size of Hail-stones?

Cleon. There is something difficult in the Theory of Hail; 'tis not easy to conceive, how such large Bodies should be instantly formed, for they can increase, in Bulk, but very little in the Time of their Descent; however, it is owing to the general Principle of freezing, after the same Manner as we see Crystals of Copper are instantly formed in Solutions of that Metal,

Metal with a requisite Degree of Cold. Then, as to their Figure, we know still less the Reason, as there seems to be nothing regular in it, unless something of a conical Form. We may suppose it is principally owing to its Motion in the Air while forming.

Euphros. Pray, what are the largest Sizes of Hail-stones that have been observed?

Cleon. I have never seen any myself exceeding $\frac{3}{4}$ of an Inch in Diameter; but I have been frequently informed of others much larger. — A Lady particularly told me, that she saw a Hail-storm abroad, where many of the Stones were as large as a *Seville Orange*. — And a Gentleman assured me, that he saw Hail-stones fall as large as common Turnips, and somewhat of the same Form; several of which he measured; one of which was full eleven Inches round. These are the largest Sizes I have ever met with in my Enquiries.

Euphros. Such Storms of Hail, I should think, were very formidable, and must produce still more direful Effects than those described by *Garth* in these Lines.

*Thus when some Storm its Crystal Quarry rends,
And Jove in ratt'ling Showers of Ice descends;
Mount Athos shakes the Forests on his Brow,
While down his wounded Sides fresh Torrents flow,
And Leaves and Limbs of Trees o'er-spread the Vale below.*

GARTH.

And again *Virgil*.

*As when thick Hail comes ratt'ling in the Wind,
The Plowman, Passenger, and lab'ring Hind,
For Shelter to the neighbouring Coverts fly,
Or hous'd, or safe in hollow Caverns lie;
But that o'er-blown, when Heav'n above them smiles,
Return to Travel, and renew their Toils.*

DRYD. VIRGIL.

And lastly, my fav'rite Author on this Subject:

*He from loose Vapours, with an icy Chain,
Binds the round Hail, and moulds the harden'd Rain;*

*The stony Tempest, with a rushing Sound,
Beats the firm Glebe, resulting from the Ground;
Swiftly it falls, and as it falls invades
The rising Herb, or breaks the spreading Blades;
While infant Flow'rs that rais'd their blooming Heads,
Crush'd by its Fury, sink into their Beds.*

BROOME.

The Course of our Enquiries leads me next to ask your Opinion concerning LIGHTNING and THUNDER.

Cleon. With respect to these *fiery Meteors*, as they are commonly called, I shall give you the best Account of them that I can learn from Sir *Isaac Newton*, who alone has reasoned justly concerning the Nature of Fire in general. From him we learn, that, when by the constant Heat of the Sun, in the Summer Time, great Quantities of Exhalations from sulphureous and other combustible Matters are rais'd into the upper Regions of the Air, and these meeting and mixing with the Nitre, an Incandescence will immediately ensue, and oftentimes real Accension, or Production of Flame; and this, if it happens in the Evening, or Night-Time, is what is vulgarly called Lightning, if it happens in any one particular Part of the Heavens only: But when the Atmosphere is more generally replete with these combustible Exhalations, they make a more general Conflagration, and burn with one continued Flame; illuminating all that Part of the Heavens in a most tremendous Manner to those who have not been used to see or think about such Things. This the Philosophers call the *Aurora Borealis*, i. e. the Northern Lights. But, indeed, there seldom a Summer passes, but more or less of this Kind may be observed about the Time of Autumn, not only in the northern, but in any other Part of the Heavens.

Euphros. Pray, *Cleonicus*, what kind of Experiments have you to illustrate this wonderful Phænomenon of fiery Meteors?

Cleon. Many of different Kinds; some of which you may easily see tried without being shocked at the Effect; for Instance;
—— You see, I take the red-hot Poker, and dropping a few Corns of Gun-powder on it, they immediately take Fire, and flash like Lightning; for Gun-powder is nothing but Sulphur, Nitre, and Coal mixt together. The Coal presently takes

Fire

Fire by the smallest Spark, by which the Sulphur and Nitre are melted, and burst into Flame, just as they do in the Heavens.

Euphros. Well! this I like to see. I am not fearful at such small Explosions. What other Experiments of this Kind can you shew me with Safety?

Cleon. Several, one of which is thus: — You see, I take this large *Florence* Flask, and put into it a small Quantity of Oil of Vitriol, with four Times its Quantity of Water, which will produce a considerable Heat, as you will find by applying your Hand to the Glass. — Then I mix with it a few Steel-filings; — upon this, you see an Ebullition, and a white Vapour arise. — In the next Place, I apply a Candle to the issuing Vapour, and it immediately takes Fire, with a bright Fulmination, or Flash like Lightning. — In the last Place, by applying the Candle several Times, you see, the like *Coruscations*, and sometimes the Flame fills the Body of the Glass, where it circulates about, and appears like an *Aurora Borealis* in Miniature. — And thus, you see, how far we can imitate Nature by Art; and that in the most terrible and tremendous of all her Works: Such Subjects as these afford the sublimest Themes, not only to the Philosopher, but also to the Divine, and the Poet. The Philosopher investigates the Nature of the Thing; the Theologist shews its important Use in the Œconomy of Providence; and the Poet renders it still more striking by the Force of Expression and Description. An Instance of this we have from *Lucan*.

*Such, while Earth trembles, and Heav'n thunders loud,
Darts the swift Lightning from the rending Cloud;
Fierce thro' the Day it breaks, and in its Flight
The dreadful Blast confounds the Gazer's Sight;
Resistless in its Course delights to rove,
And cleaves the Temples of its Master Jove:
Alike where'er it passes or returns,
With equal Rage the fell Destroyer burns;
Then with a Whirl, full in its Strength, retires,
And recollects the Force of all its scatter'd Fires.*

ROWE'S LUCAN.

Another Instance we have from the *Iliad*.

*As when by Lightnings Jove's ætherial Pow'r
Foretels the rattling Hail or weighty Show'r,
Or sends soft Snows to whiten all the Shore,
Or bids the brazen Throat of War to roar;
By Fits, one Flash succeeds as one expires,
And Heav'n flames thick with momentary Fires.*

POPE'S *ILIAD*.

Euphras. These are very beautiful Imitations, indeed; and since you have recommended Mr. Thompson's *Seasons*, I remember a Passage there, as much to the Purpose on the *Aurora Borealis*, which he thus very poetically describes.

*Oft in this Season, silent from the North,
A Blaze of Meteors shoots; ensweeping first
The lower Skies, they all at once converge
High to the Crown of Heav'n, and all at once,
Relapsing quick, as quickly reascend,
And mix and thwart, extinguish and renew,
All Æther coursing in a Maze of Light.
From Look to Look contagious thro' the Croud
The Pannic runs, and into wond'rous Shapes
Th' Appearance throws: Armies, in meet Array,
Throng'd with aerial Spears and Steeds of Fire;
'Till the long Lines of full extended War,
In bleeding Fight commix'd, the sanguine Flood
Rolls a broad Slaughter o'er the Plains of Heav'n.*

THOMP. *SEASONS*.

But to bring up the Rear of these dire Phenomena, let *Thunder* next employ our Attention. Pray, what is the Nature and Cause of that?

Cleon. THUNDER, properly speaking, is neither a Phenomenon, nor a Meteor, as it consists altogether in Sound; for you are to know, that when the combustibile Matters in the Heavens take Fire, or kindle into a Flame, if there be no Resistance, they only explode, or flash away without any Thing more than the Phenomenon

Phænomenon of Lightning, which is generally the Case of a rare and unconfined Air, as we often see in the autumnal Evenings; but the Case is far otherwise, when these fermenting Matters are contained in the dense Body of a Cloud. The great Resistance which they meet with, in this Case, occasions an equal Power of re-action, which is spent wholly on the Body of the Cloud and ambient Air; which Air, by this Means, having its Vibrations excited in the highest Degree, occasions those very loud Reports from the upper Regions, and expanding over all the inferior Parts of the Atmosphere, propagate those awful Sounds, which we call THUNDER; for Sound, you must know by the Way, consists only in the pulsive Motion of the Air, which I shall more fully explain to you, when I come to speak of the more pleasing Modulations of this Medium, producing the more agreeable Notes, which make Harmony and Music.

Euphros. I cannot tell which will entertain me most. The loud Voice of Thunder so strangely affects the Powers of my Mind, as to be agreeable and terrible at the same Time; and you see, I am a Devotee to Music, by my constant Application to the Practice and Study of it; and I must say this for myself, that, if I have any Ingenuity, it lies, principally in my Fingers Ends. I shall long for a Lecture on Music; but, at present, pray, go on with your *celestial Thorough-bass*.

Cleon. To tell you the plain Truth, tho' I am a young Man, I am yet an old-fashioned Philosopher, and cannot help thinking, that Sir *Isaac Newton's* Method of explaining the Causes of these great Effects is much preferable to any new Hypothesis of the Moderns. He tells us, in his Treatise of Optics, that Lightning in the Heavens, is analogous to the Flashing of Gunpowder unconfined, and that Thunder is a similar Effect to the Report of a Gun from the Powder kindled, but confined in the Barrel; and to those other chymical Explosions, from what they call *Pulvis & Aurum Fulminans*, which are Powders; such as, when laid upon the Point of a Knife, and held over a lighted Candle, explode with a very sudden and loud Report; which Sort of Experiments are so shocking, that I shall not terrify you with them.

Euphros. I shall take your Word, *Cleonicus*, for that, as I am not fond of seeing any Thing that is shocking and terrible; and so affected is my Mind with the Thoughts of Thunder, that

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that, when any Thing of that Kind is likely to happen, I generally get into a Corner, as it were, to avoid the Blow. I had much rather read the Description of it in the Poet; and it even makes me shudder then, as in the following Lines of Dr. Broom,

*Mean Time, from ev'ry Region of the Sky,
Red burning Bolts in forky Vengeance fly:
Dreadfully bright o'er Seas and Earth they glare,
And Bursts of Thunder rend th' encumber'd Air;
At once the Thunders of th' Almighty sound,
Heav'n lowers, descend the Floods, and rocks the Ground.*

BROOME.

But more particularly the Description of a Thunder-storm by Mr. Thompson, in the following Lines.

*How chang'd the Scene! in blazing Height of Noon,
The Sun, oppress'd, is plung'd in thickest Gloom.
Still Horror reigns, a dreary Twilight round
Of struggling Night, and Day malignant mix'd.
Far to the hot Æquator crouding fast,
Where, highly rarify'd, the yielding Air
Admits their Stream, incessant Vapours roll,
Amazing Clouds on Clouds continual heap'd;
Or whirl'd tempestuous by the gusty Wind,
Or silent borne along, heavy and slow,
With the big Stores of streaming Oceans charg'd.
Mean Time, amid these upper Seas, condens'd
Around the cold aerial Mountain's Brow,
And by conflicting Wings together dash'd,
The Thunder holds his black tremendous Throne;
From Cloud to Cloud the rending Lightnings rage;
'Till, in the furious Elemental War
Dissolv'd, the whole precipitated Mass
Unbroken Floods and solid Torrents pours.*

THOMP. SEASONS.

I recollect at present but one Thing more to enquire about, relative to these Subjects, and that is what has often filled me with the

the greatest Horror; I mean, what is usually called a *Thunder Bolt*. Pray, what is your Opinion of that?

Cleon. This is an Affair of the most solemn Consideration, and must certainly fill every reflecting Mind with Horror, when we consider the many dreadful Effects that are often produced by it: Instant Death is the immediate Effect of its Stroke in Animals.——The strongest Trees are rent and torn a sunder——The finest Buildings at once demolished, and the hardest Metals in a Moment dissolved.——Such are the Effects of the greatest and most formidable Powers in Nature. The Substance of these Bolts consists of a compact and undissolved Body of ignited Matter, which has not time to explode in the Air, but is darted, with the Velocity of Light itself, to the Objects on the Surface of the Earth, which it strikes with an inconceivable and irresistible Force, destroying the Nature and Texture of every Thing that stands in its Way. Not only our Histories, but even our Memories retain but too many Instances of these dismal Effects. We may consider the Matter of Lightning in three different States; the First is, that, in which it only explodes, and flashes away without any Force to do Harm; the Second is, when it explodes with greater Force and Density; the Effects of this are oftentimes too sensible at a Distance, striking the unhappy Spectator with Blindness, and setting Fire to Stacks of Corn, Houses, &c. the Third State is that of the Thunder-bolt; but I have said enough on this Head. We shall take the next Opportunity to consider the Nature of *Electricity*; a Subject nearly allied to this, but whose Phænomena and Effects are more innocent, and much more entertaining.

DIALOGUE VI.

*On the Nature, Phænomena, and Experiments of
ELECTRICITY.*

Euphrosyne.

YOU very agreeably concluded our last Conversation by promising to give an Account of the Nature of Electricity, which

which you then told me had some Relation to the Nature of Lightning, and Thunder.

Cleon. I did; and you may now expect as much on that Subject as I know of the Matter myself, which, to say the Truth, is not a great deal. However, its Relation to Lightning and Thunder is obvious, and consists in the following Particulars, 1. It consists of a fine ethereal Matter, which, when sufficiently condensed, appears in the Form of Fire, and such is the Case of the Matter of Lightning. 2. In a State of Condensation, this electrical Matter, like that of Lightning, is strongly elastic and explosive. 3. It will produce, when sufficiently dense, the Effects similar to those of Lightning, in burning, and setting Fire to other Bodies. 4. It produces, in the Explosion, a very sensible Report, which may be esteemed a Kind of Thunder in Minuature. 5. The Effects of such an Explosion is very sensible; and sometimes very great on the animal System; so as to produce, not only Uneasiness and Pain to a great Degree, but even to inflict Death itself; for not only Birds and smaller Animals, but Man himself has fallen a Victim to its Force. 6. The Velocity of electrical Matter is like that of Lightning, almost instantaneous, and probably the same with that of Light itself.

Euphros. These are wonderful Properties of Matter indeed! Pray, how came they at first to be discovered?

Cleon. The Properties of Electricity, like most other Things, received a gradual Discovery and Improvement; and it is now become almost a Science. It has been always observed, that Amber, Jett, Sealing-wax, Glass, and other elastic and polished Bodies, would, upon rubbing, attract and repel light Bodies, as Hairs, Feathers, Down, Dust, &c. and as this Property was most conspicuous in Amber, which in *Greek* is called *ἤλεκτρον*, *Electron*; therefore this peculiar Power of that Body was called *Electricity*.

Euphros. But I suppose, but little of this Affair was known till lately: How far, pray, might the Knowledge of the Antients extend in this Particular?

Cleon. It was scarce any thing more than a few entertaining Experiments; for by rubbing the Pieces of Amber, Sealing-wax, &c. they would often innocently amuse themselves with

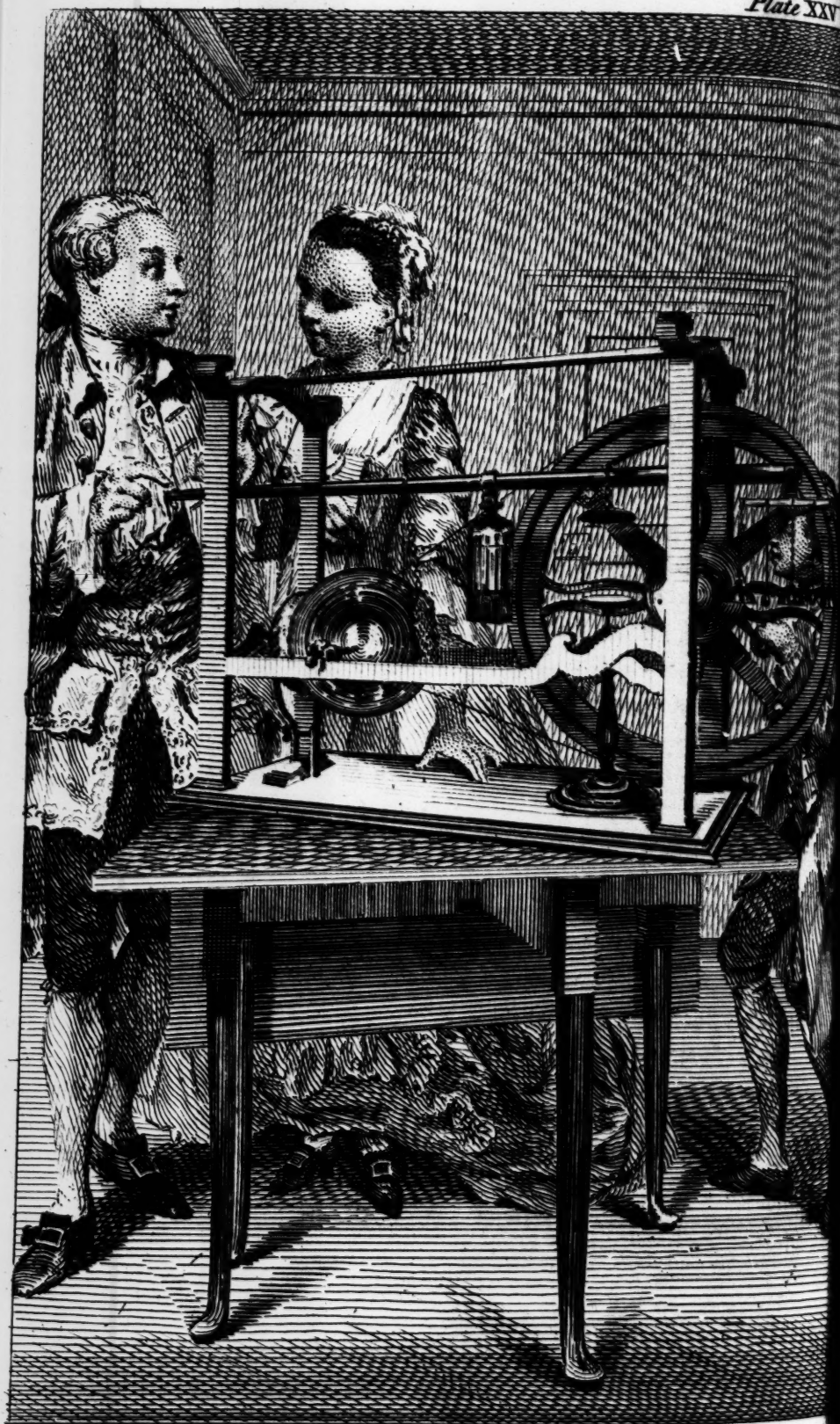
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A New ELECTRICAL MACHINE for the TABLE

with the Attraction and Repulsion of light Bodies of different Kinds and Forms; some of which I shall shew you for your present Entertainment. — Thus, you see, this Piece of Amber in the Head of my Cane, when gently rub'd by my Glove, it attracts the Hairs, the Feathers, and these small Pieces of Leaf-Gold. — I rub this Tube of Glas in the same Manner, and it attracts those Objects still more strongly.

Euphros. Well! this is very pretty indeed; but I observe, they are not only attracted, but soon afterward repelled from the Tube. Pray, *Cleonicus*, how is that to be accounted for?

Cleon. Why, truly, my *Euphrosyne*, this is a Kind of occult Philosophy: However, you must understand, that, upon rubbing of the Tube, there is a Motion produced of this Electric Ether from the Parts round about it towards the Tube, or Piece of Amber; and these fine Particles, in their Way, lay hold of those light Bodies, and carry them with themselves to the Tube; so that, in reality, tho' this Appearance seems in itself an Attraction, it is really produced by the Impulse of these ethereal Particles; and when these light Bodies have touch'd the Tube, and become themselves possess'd of the electric Matter to a proper Degree, they then fly off, and, I believe, in this Case, may be properly said to be repelled by the Tube.

Euphros. But, pray, *Cleonicus*, can you, by any Experiments, shew me this Matter of Electricity; for otherwise it is talking to me in the Dark?

Cleon. Yes; come with me into this dark Room, and then you will view it in its proper Light. —

Euphros. — Well! it is dark enough sure. — What am I to see here?

Cleon. You will now see in the Dark what you could not before perceive in the Light. — I rub the Tube with a Piece of Silk, and you see the Sparks of Fire. — I rub it still more briskly, and you see the Sparks changed into Flashes; — Flashes many Inches in Length, and very much resembling the forked Lightning of the Skies.

Euphros. I do; and it is amazing, as well as very entertaining to behold. — I not only see, but hear it likewise. What is it I hear like the Crackling of a green Leaf in the Fire?

Cleon. The crackling Noise you hear is occasion'd thus, After I have given a brisk Stroke downward upon the Tube, I carry my Hand quick along by the Side of it, upwards, at a small Distance; by this Means the electric Matter is condensed between the Hand and the Tube, in the several Parts of it, which occasions the small successive Explosions, or Snap-pings, which you hear.

Euphros. Well! these Corruscations and Explosions are very surprizing indeed; I could never have thought there were such Powers in Nature, had you not convinced me of them by Experiment, — and is it this Fire that I now see, that fetches and carries those light Bodies to and from the Tube?

Cleon. It is in the light Room the invisible Agent that produces these Effects. At present we shall leave our dark Apartment to explain another Property. — You observe, my *Euphrosyne*, that, when the Piece of Leaf-Gold, or downy Feather is once repelled from the Tube, I pursue it with the Tube, and constantly keep repelling of it; nor, if the Tube be strongly excited, will it come to it again, till it has touched some other Body.

Euphros. 'Tis pleasant enough to see how you persecute the Feather. They seem to endeavour avoiding the Tube by every Method of Flight, but how do you account for the Reason of this odd and comical Appearance?

Cleon. These Bodies in contact with the Tube are fill'd with the electric Virtue, which, as I said before, as soon as they have received to a sufficient Degree, will be repelled, and will be continually repelled so long as they are overcharg'd with this electrical Matter; for we shall always find by Experience, that, when any two Bodies are possess'd with one and the same Power, whether of Electricity, Magnetism, or Gravity, there will be always a Circumstance, in which they will constantly repel each other; but when one of those Bodies comes to touch another, not so replete with this Virtue, it will impart the Surplus of its Electricity to that other Body, and be reduced again to its original State; and hence the Reason why they fly so quickly backward and forward between the Tube and the Table. Since as fast as they receive it at one, they discharge it at the other.

Euphros.

Euphros. I know not whether I understand you perfectly. Do you mean, that Bodies in general are possess'd of a certain Quantity of this Force, and that they receive more by the excited Tube, and by that Means become repelled; and that, when such a Body touches another that is not electrified, it loses all that is over and above its natural Quantity, and then is liable to be attracted again?

Cleon. That is the very Case, so far as I have hitherto proceeded; but one Thing more is to be observed, that Bodies will be liable to be repelled, not only when they have too much, but also when they have too little of the electrical Matter; and further, that some Bodies will fill others with a greater Quantity of Electricity than they naturally have, in which Case they are said to *electrify them positively*; and other Bodies are found, that, when excited by rubbing, will dispossess such as touch them of a Part of what they naturally contain, and these are then said to be *electrified negatively*.

Euphros. This positive and negative Doctrine of Electricity is something so new to me, and the Subject of Electricity such as I am so little acquainted with, that I scarcely know what to make of it, or how to fashion my Intellects for understanding it. I must beg your Assistance in this Case, if possible, by Experiments.

Cleon. That I shall do very readily. Now observe, I tie a fine Feather to a Thread of Silk, and electrify it with the Tube very strongly. — It is now constantly repelled by the Tube, you see. — I now take the Stick of Sealing-wax, and excite it, and upon applying it to the Feather, it immediately attracts it. — So likewise the Piece of Leaf-Gold is constantly repelled by the glass Tube. — But you observe, it is immediately attracted by the excited Wax. In short, every Thing repelled by Glass is attracted by Sealing-wax, Amber, Jett, and such-like Bodies; and as these consist for the most Part of resinous Substances, it occasions the two-fold Distinction of a *resinous* and *vitreous Electricity*. But upon a more nice Consideration of this Affair by the Moderns, it is found, that Glass electrifies Bodies by adding to their natural Quantity, and other Bodies by diminishing it, therefore we have now the new Distinction of *Glass* electrifying *positively*, and *resinous* Bodies *negatively*. Some other Experi-

ments will tend to illustrate this Affair more fully. But before we come to them, I must observe to you, that some Bodies will communicate Electricity from one to another, and others will not. Thus, if I hang a Feather by a flaxen Thread, the Electricity will pass from the Feather through that Thread to any Piece of Wood, or metalline Substance, it is suspended by, and this Thread is, in such a Case, term'd the *Conductor of Electricity*.

— By this Means, you observe, when I apply the excited Tube to the Feather, it is constantly attracted; because the electrical Matter is carried off by the Thread as fast as it is received by the Tube. — On the other Hand, you see, another Feather suspended by a silken String, and another by a Horse-hair, both perfectly dry, and upon applying the Tube you see they are constantly repelled; the Reason of which is, that those Bodies will not of themselves conduct, or carry off the Electricity from the Feather, being some how or other disqualified for that Purpose, and are on this Account ranged among the Number of *electrical Bodies*, and sometimes are called *Electrics per Se*; whereas those that conduct Electricity are call'd *Non Electrics*. Thus much was necessary to premise, by Way of Definition; but what relates to the *Rational* of the various *Phænomena* of *Electricity*, you will be better able to understand, after you have seen them illustrated by Experiment; for which Purpose I have provided you this large Machine.

Euphras. A large and elegant Machine indeed; but I observe, you have here a large glass Globe. To what Purpose does that serve? I suppose, to answer the End of the glass Tube more compleatly, does it not, *Cleonicus*?

Cleon. Yes, that is the Design of it; for having a large Surface the Electricity is excited, when the Globe is put in Motion, from the Attrition of the Cushion behind, in a much larger Degree than we can produce it from the Tube, and more constantly, by turning the Wheel; so that upon the Whole, it is much better fitted to answer the Purposes of Experiments.

Euphras. I see you have here a large Gun-barrel suspended by silken Strings over the Globe. I partly guess the Reason of that, from what you said of the Feather's being suspended by a silk or Hair-line.

Cleon. That you may do very nearly; for by Means of the Conductor, which is the brass Equipage hanging from the Barrel

against

against the Globe, the electrical Matter is convey'd to the Barrel, but can go no further, by Reason of the renitent Quality of the filken Strings. By this Contrivance, the electric Fluid, thrown out by the Glass, will be collected and accumulated in the Barrel, ready to be dispensed in small Quantities to every non-electric Body that shall approach it, in the Form of a Spark, and snap, or else in a continued fine Stream of Fire.—This you see and hear, by my approaching the Knuckle of my Finger to the Barrel. — Now you are to do the like, *Euphrosyne*.

Euphros. Truly, as there is Fire in the Case, I am afraid. — Does it not give you Pain, *Cleonicus*?

Cleon. Not in the least. You'll scarcely feel it. — Apply your Finger within a Quarter of an Inch, and it will do. —

Euphros. Well! I did not think I was so Faint-hearted. I find a strange Reluctance to trying this Experiment, tho' there seems to be nothing in it. — Well! I'll pluck up my Courage and try. — Is my Finger near enough now? — Dear me! it strikes before I was aware; but the Sensation is rather agreeable than otherwise. — I can now take off as many Sparks as I please, — and by continuing my Knuckle near the Barrel, I perceive a constant Flame of purple Fire flowing toward it. — These Things are very wonderful as well as pleasant. I could not have thought there had been any such Powers in Nature.

Cleon. You express the Sentiments of all who first view these curious Appearances. I shall now proceed to shew you still greater Things than these. — You observe here a four Ounce Phial, filled with Steel-filings, coated on the Out-side with a Piece of Leaf-Tin, with an Iron Wire and Loop upon it; also, in the Top, you observe a large Iron Wire pass thro' the Cork among the Steel-filings to the Bottom; the outer Part of this Wire is turn'd into the Form of a Hook, by which it may be hung on the Gun-barrel, — as thus you see it.

Euphros. Very good! And to what Purpose is all this Apparatus in the Phial?

Cleon. By this Contrivance, the Force, or Power of electrical Fluid may be increased to a considerable Degree. You did but just feel the Spark before, but now, if you take the Phial in

one

one Hand, and a Spark from the Barrel with the Finger of the other, you will find a more sensible Effect; and this you must do, before you can properly be said to know the Nature, or Power of Electricity.

Euphros. I thought you would bring me into a Scrape e'er long about this electrical Fire and Force. I am loath to try the Experiment with this Phial in Armour; it seems to require a martial Courage, and how can you expect me to stand Fire before I know the Nature of the Artillery? — Pray, *Cleonicus*, can't I understand it by seeing you do it yourself?

Cleon. Not in the least; you might as well expect to be cur'd of an Ague by my taking the Bark for you. — However, it will not be fair to desire you to try the Experiment till you have seen that no Harm can accrue by it, and therefore I will try it first. — I take the Phial in my Right-hand; — with my Left I take off the Spark. — The Effect is an odd Kind of Shock in the Elbows; — but it is over in a Minute. — I shall take Care to moderate the Force to you, and therefore you may try it without Fear.

Euphros. What you advise, or injoin, I think myself oblig'd to submit to; therefore whirle the Globe about, and charge the Phial. — I take it in my Hand; — and now for the Snap. — I am electrified in Truth. — It made me jump again. What an unaccountable odd Kind of Stroke it gives to my Elbows! — I hope I have nothing more to suffer worse than this; if there be, I shall not very well like it.

Cleon. You may comfort yourself, that the Worst is past. This is the *Coupe de Grace*, which is what all that adventure in Electricity must expect to meet with; — but tho' you make so much of this Affair, I can assure you, I have seen many a Lady with so much Presence of Mind as to sustain many of these Shocks one after another.

Euphros. In every Age we may expect a *Semiramis*, or a *Boadicia*; but nevertheless, the generality of our Sex will never think themselves designed to bear Arms. When you expect Mankind to sport with your electrical Fire and Shocks, you ought to have your Room fill'd with Officers of the Military Order, and not to expect such Courage from Females.

Cleon.

Cleon. What would you think, my *Euphrosyne*, if I were to tell you, that I have seen a Lady with greater Intrepidity encounter the electrical Efforts than any one of our Sex; and I can assure you from Experience, that I have seen a greater Number of Gentlemen than of Ladies refuse to stand the Shock; and it altogether depends upon the peculiar Make and Frame of a Person's Mind; for I have more than once observed a Person, who had signalized himself for Valour in the Field of Battle, could not by any Means be prevailed on to take the Phial in his Hand; but enough of this.——We proceed to our Experiments, of which I shall entertain you with a select Number of those which are most considerable, leaving the Rest for your Amusement at your leisure Hours when alone.

Euphros. If you shew me some of the Principal it will be sufficient. I shall learn the Method of Practice from them. Pray, what will you begin with?

Cleon. You see here a semicircular Piece of Cane, with several Feathers suspended by silken and linen Threads alternately; these I place at a small Distance from the Globe, and when it is excited, you observe all the Feathers hanging by the linen Threads will be immediately attracted to the Globe, and constantly kept in an oblique Position, and directed severally to the Centre of the Globe; while those between them on silken Strings seem but little affected, and remain in their perpendicular Position.

Euphros. This is a very pleasant and pertinent Experiment. I plainly perceive the Drift of it, you hereby shew me, that the Feathers on the linen Threads lose all their electric Matter as fast as they receive it, and therefore are constantly attracted; while those suspended by silken Strings, retaining their electric Matter first received from the Globe, will always afterwards be repell'd by it. Pray, what is your next Experiment?

Cleon. This Wire you see has three large plummy Feathers fix'd on the Top of it, and I put it into the End of the Barrel.——Upon turning the Globe, you see the Feathers immediately bristle out, and all the Plumage expanding itself every Way as far as possible.——If I approach my Finger to the Feathers, the *Plumule* all bend themselves to my Finger.——If I move my Finger this Way or that, they all move after it, as if alive.——If I put my Finger to the Barrel, and take off a Spark, the *Plumule*

mulæ all collapse, and fall close to the Feather. — My Finger removed, they become erect, and bristle out as before.

Euphros. Nothing can be a more delightful Spectacle. I presume the Plumage puts on this Appearance from having the electric Matter equal in all the Parts, by which the *Plumulae* constantly extend themselves, and repel each other; but when the Finger approaches, they become attracted by it, and discharge their electric Fluid in it. Also, when the Finger takes the Spark from the Barrel, it not only draws the Electricity from the Barrel, but likewise from the Feathers themselves, by which Means the Plumage becomes unelectrified, and naturally falls down. — I presume I am right so far, *Cleonicus*.

Cleon. You have given the true Reason of the Phenomenon, and the next Experiment I shall shew you is to be accounted for the same Way. — I take this whole Leaf of Gold, and tumble it together upon this Plate. — I bring the Plate under the Gun-barrel, and you see the Gold-leaf rise from the Plate, expand itself out into a perfect Plane, — with one Corner to the Gun-barrel, and the Opposite one to the Plate, — moving very quickly backward and forward between both. — I lower the Plate to a proper Distance, and you see the Motion of the Leaf ceases by Degrees, and it becomes suspended in *Equilibrium* between both.

Euphros. This is a most wonderful and curious Sight. I now see it is possible for the heaviest Bodies to be suspended in the Air upon nothing; for I can plainly perceive there is a considerable Distance between the Points of the Leaf-Gold and the Barrel and Plate.

Cleon. But you must be aware of Mistakes, my *Euphrosyne*. The suspended Leaf of Gold is, as it were, supported by Pillars of Fire; for it is by Means of the Electricity which it receives from the Barrel, and communicates to the Plate, that it is suspended equally between both; and this will appear in the Form of Fire, when we put to the Window-shutters, and make the Room dark. — For now you see the Experiment in its proper Light.

Euphros. I do. — I see it connected with the Barrel and Plate at either Corner by a Stream of Fire. —

Cleon

Cleon. ——— I put my Finger on the Barrel. ——— And the Leaf falls down at once on the Plate. ——— My Finger taken off, the Leaf rises up, and becomes suspended as before.

Euphros. We may now open the Windows again, as I have seen the Manner of this Experiment thoroughly. Pray, what is your next Phænomenon?

Cleon. I take some fine Sand on this Plate, and place it on the Pedestal under the Barrel, and you see, as it were, a Hurricane ensue among the Particles of Sand. ——— They are agitated upwards and downwards, and driven every Way in Commotion, 'till at last, they are all dispersed, and, as it were, blown off from the Plate.

Euphros. This is something of a merry Scene, and has much the Appearance of an artificial Storm.

Cleon. Another curious Experiment is this. An eight-pointed Plate of Iron, in form of a Star, freely moveable upon an Axis, and placed on the End of the electrified Barrel, you will see a bright Flame on each of the Points. [*Window shut.*]

Euphros. It is a most pleasing Sight, indeed! I observe every Point illuminated with a small Flame. ———

Cleon. ——— I put my Finger on the Barrel, and all those little Lamps are extinguished. ——— I take my Finger off, and in an Instant, they are lighted up again. ——— But what see you now, my *Euphrosyne*?

Euphros. See! a wonderful Sight, a real Circle of Fire. Pray, what have you done to make that Appearance?

Cleon. Only put the Star into a circular Motion, by striking it; and now the several luminous Points succeed so fast to each other, as to make the Appearance of a Circle of Fire. ——— This Circle, you see, disappears too, in taking the Spark from the Barrel. [*Window opened.*]

Euphros. Why this would pass for a Sort of Conjuration in Countries where Electricity has not been heard of.

Cleon. It would so; and nothing would be more easy than to impose upon People this Way; but it happened very luckily to fall into such Hands, whose Interest was rather to divulge than make a Secret of it; for, by the next Experiment, you will observe, that nothing is easier than to draw Fire from every Part of your Body, and that without darkening the Room.

Euphros. This is something more extraordinary still; but sure I do not understand you.

Cleon. Why, then you shall try the Experiment upon me, and prove the Truth of it that Way. — I take this little Board with four Glass-feet, and stand upon it: — Then I take the Chain in my Hand, which is connected with the Gun-barrel at the other End. — This conducts the Electricity to all the Parts of my Body; — but it cannot go off by Reason of the Glass below, which will not conduct Electricity. — I am therefore, in this Situation, properly said to be electrified. — I now hold out my Hand to you. Pray, take off a Spark. —

Euphros. Amazing indeed! — The Spark proceeds from your Hand most evidently to my Finger: — From your Cloaths it is the same: — From your Legs: — From your very Shoes, the Fire issues out. — Pray, what Kind of Sensation does it cause in you?

Cleon. That you will best know by taking my Place. [*She stands on the Board*] — Don't be afraid; but hold out your Hand. — I take off the Spark from your Finger: — From your Shoulder: — From your Foot: — From your Nose: — And to conclude all, my *Euphrosyne*, let me salute you in that Situation; — but you see we endeavour it in vain. — Our Lips cannot touch, repelled, as it were, by the irresistible Force of electrical Fire.

Euphros. Well! were it not for Experiments, it would be impossible for a Person to gain Belief of such Things. I could never have thought of a Person's being all on Fire without knowing it; or that Fire could have been extracted from every Part, without any more Sensation than the touching of a Pin's Point.

Cleon. These wonderful Discoveries are all of modern Date. The Gentleman is now living, who first accidentally discovered the prodigious Increase of Force, by Means of the coated Phial, and of Course, was the first who sustained that very great Shock. He paid for the Discovery indeed, by the Privation of his Senses for some Time. This was the celebrated Mr. *Muschenbroek*, the present Professor of Philosophy at *Leyden*; and indeed, this is the Foundation of most of the Improvements and great Discoveries that have been made in Electricity to this Time; I shall take an Opportunity of shewing you, at another Time, that

that the electrical Virtue will go through any Number of Persons, communicating with each other, and give them a Shock all at the same Instant of Time ; but at present, we shall try the Experiment in a less Circuit, *i. e.* only you, myself, and your little Lap-dog, *Chloe*, between us both.

Euphros. How can you be so cruel, dear *Cleonicus*, as to think of my little *Chloe*? ——— The pretty, tender Creature will be at least frightened out of its Wits, if not expire with the Shock. Pray, let me beg the dear little Creature off.

Cleon. By no Means, my *Euphrosyne*, *Chloe* must not be excused ; if she dies, it will be in her Mistress's Arms ; and where can she make her Exit with more Satisfaction? ——— But I only joke with you, it will not do her the least Harm. It may make her yelp perhaps, and that will be all.

Euphros. I can't say but I'm more afraid of my little *Chloe* than I am of myself. However, she shall know for once what it is to be electrified. ——— And here she is ; but pray, let me hold her fast in my Arm.

Cleon. That you may do, and with the other Hand, take hold of the Chain, which hangs from the Phial, and let me, with one Hand, take hold of *Chloe*'s Foot, and with the other, I shall take off a Spark, when the Bottle is charged. ——— Are you ready?

Euphros. I am. ——— You may touch off the Spark as soon as you please. ——— Heavens ! she's gone, and I'm afraid has broke her Neck in the Fall. ——— Poor, little Creature ! how it cried out ! ——— I can assure you, I was almost ready to stumble myself, for the Shock was greater now than before. For the future, you must excuse both me and my *Chloe* from any such Kind of Experiments ; for we shall both remember this as long as we live.

Cleon. What would you say, if you were to see your favourite Linnet struck dead with the Shock?

Euphros. I would not see it, nor suffer it for the World. This Electricity, I'm afraid, will prove a terrible Affair to my poor little Dog and Birds. Why should you take Delight in such cruel Experiments?

Cleon. Were it not for them, Mankind would not be informed how far the Power of Nature could operate, and con-

consequently, in many Cases, what could, or could not be done. Nay, the Life of a Bird, or a Mouse, might probably save that of a Man, and therefore the Experiments tend rather to a good, than a bad End; tho' in Appearance they seem incompatible with our Reason, and more delicate Passions. Accordingly therefore, I have prepared this little Titmose to be a substitute Victim for your Linnet, and you must not flinch to see it sacrificed on this Altar by electrical Fire. — I shall call my Servant in to be the Executioner. — Here, *John*, take this Bird, with a Chain about its Leg, and when I speak, bring its Head within $\frac{1}{4}$ of an Inch of the Barrel.

John. — Yes, Sir, I am ready to obey your Commands.

Cleon. Gently now bring its Head to the Barrel. —

John. The Bird's dead, by my Soul! —

Euphros. Poor Creature! It is dead indeed! How sudden a Death is this! What a violent Stroke it must be on the Head of that little Creature to deprive it of Life in an Instant! But these Scenes are so affecting, I could wish to have them chang'd for Experiments of another Sort.

Cleon. Well! I shall entertain you now with a few others which are more innocent and less offensive. — You see I take this crooked Wire, and hang it to the Gun-Barrel with a Weight at the Bottom to keep it steady, and on the sharp Point at Top I place this long Piece of Brass, nicely balanced with a Ball at each End, so as to move very freely. — This brass Fly is now electrified, and when any non-electric Body is applied to it, it will appear to be attracted this Way and that, and may be carried round as often as you please. — Thus my Finger held near it brings it immediately so near, as to discharge its Fire with a Snap. — I take my Finger on the other Side, and the brass Ball follows it; in short, my Finger seems to attract it, as the Load-stone does the Magnetic Needle.

Euphros. This is really a very pretty Phænomenon! And now you speak of the Magnetic Needle, I should be glad if you would satisfy my Curiosity in one Particular; that is, to let me see, if the Magnetic Virtue is affected by this electrical Matter, or if the Needle be attracted by the Load-stone in the same Manner, when electrified, as when not.

Cleon.

Cleon. You will see this Matter determined by Experiment. I have a Needle at Hand for that Purpose. — I place it on the Point of the Wire. — Tho' it is now electrified strongly, yet it observes its true Point of Variation. — I approach the Magnet, and it is attracted; — I remove the Magnet, and it returns to its former Position. — I apply the other End of the Load-stone, and it is repelled. — On removing it, it returns again to its Variation as before. — In short, the Needle, like the Pieces of Brass, is attracted by every non-electric Body, but repelled by the Magnet only.

Euphros. I am now fully convinced, that those two wonderful Powers do not interfere with each other, or hinder each others Operation. Pray, how does the electrical Virtue affect the Motion of Fluids?

Cleon. In a very curious Manner, in three Respects. First, It alters the Direction of the Motion. 2dly, It accelerates, or increases the Motion. And 3dly, It renders the Fluid luminous, or gives it the Appearance of Fire itself.

Euphros. Such Experiments as these greatly delight me, and I hope will not be very troublesome to yourself.

Cleon. Not in the least, my *Euphrosyne*. We have always Instruments ready at Hand to exhibit these Appearances. — With this brass Syringe, and Pipe at the End with a small Bore, I shall make a very fine Stream of Water, which, by the Force of the Piston, flies to a great Distance. — At the same Time, take you this glass Tube in your Hand, and when you see the slender Stream, give it a Stroke or two with your Glove, and hold it near to the Stream, and you will see the Stream immediately attracted by it, and bent considerably out of its first Direction towards the Tube.

Euphros. I am ready with the Glass, and will observe your Directions. — It is a very fine Vein of Water, indeed! — And on applying the Tube, I see how curiously it is attracted thereby; and from going strait along the Room, it is bent so as to besprinkle the Glass on the Side of it. — This I could scarcely have imagined, had I not proved the Fact.

Cleon. The Experiment to prove the Acceleration of Fluids by Electricity, will equally please you. — It is performed by this small *Capillary Siphon*, which hangs from a small Bucket of

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of Water on the Gun-Barrel, which before it is electrified carries off the Water by a gentle Dropping only; — but, on the Globe's being excited, and the Water electrified, the Dropping of the *Siphon* is changed into a continual Stream. — On applying my Finger to the Barrel, the Electricity is interrupted, and the *Siphon* again only drops. — My Finger taken away, the *Siphon* runs a Stream, and these alternate Operations of the *Siphon* are repeated as suddenly, and as often as you please.

Euphros. This Experiment is very wonderful indeed! And from what I see here, I should be induced to believe, that if a Person was to be let Blood, and at the same Time electrified, it would have a considerable Effect upon the Stream of Blood issuing from his Arm.

Cleon. Indeed it would! The fine Vein of effluent Blood, as soon as the Person becomes electrified, would be accelerated, and consequently be thrown to a greater Distance; and, if you chuse it, my *Euphrosyne*, the Surgeon shall be called in, and the Experiment tried upon yourself.

Euphros. Indeed not I! my Curiosity is not so great, nor am I so much a Friend to Phlebotomy, as to suffer this Experiment: And, indeed! rather than it should be tried on any Person, I had rather take your Word for the Truth of it, as I see there is so much Reason to believe; and therefore proceed to your next Experiment, and shew me how the Water is changed into Fire.

Cleon. This I shall do by the very same Experiment of the *Siphon* as before; only I now put to the Window-shutters. — The Room is made dark, and you observe before the Globe is moved, no Appearance of Drops from the *Siphon*; — but the Globe being excited, you see a fiery Stream descend from the *Siphon*. — My Finger placed on the Barrel, the Stream disappears. — When removed, the Water descends in the Appearance of Fire again. — Moreover, if I apply my Finger to the Surface of the Water in the Bucket, it yields an Eruption of Electrical Fire with the usual Explosion.

Euphros. This is a strange Kind of Philosophy, indeed! Sure no other Art could produce Fire from Water! two Elements so opposite to each other in their Nature, and yet so intimately connected in these Experiments.

Cleon

Cleon. All the Works of Nature are wonderful; and what renders many of them not so is only their being the common Objects of our Senses. — But I open the Windows again to shew you another Experiment. — You see here a small Apparatus of three Bells, with two Clappers between them. — These will afford you a pretty Peal by Electricity.

Euphros. You know how fond I am of Music; but the Ringing of Bells by Electricity is what I have never yet so much as heard of. Pray, how is this effected?

Cleon. These three Bells, you see, hang from the stait Piece of brass; the two at the Ends are suspended by small brass Chains; but that in the Middle by a silken String. From the Center of this Bell, you observe, a Chain goes down to the Table; and lastly, the two small Clappers, between the Bells, are each suspended by a silken String.

Euphros. This is a pretty Kind of electrified Belfry enough! and I partly see the Reason of this nice Disposition of the Bells and the Clappers; for as it hangs to the Barrel, the Electricity is conducted to the two extreme Bells, by Means of the Chain. These, being thoroughly electrified, will attract the Clappers, and communicate their Electricity to them: These Clappers being suspended by silken Strings, it cannot go off by them; the Consequence of which is, they will be repelled from the outmost Bells, and be made to strike against the Middle one; from whence it will run off to the Table, by the Chain which hangs from it: The Clappers, having by this Means, discharged their Electricity, will be again attracted by, and strike the two extreme Bells, and being thus alternately attracted and repelled, they must necessarily strike, and ring the Bells.

Cleon. You understand the Theory of this new Kind of *Campanalogia* very well; and you may observe, that, if there were ever so many of these Bells, these require but one Man to ring them all, viz. the Man at the Wheel; for no sooner does he turn the Wheel, than the Clappers are all in Motion, and you hear the Music of the Bells. — If I put my Finger on the Barrel, the Clappers all stop at once, and you hear no more of the Sound. — The Moment I remove my Finger, the Clappers go, and the Bells are ringing again. — I put too the Window-shutters, and the Strokes of the Clappers are at-

tended with Explosions of Fire. — I place my Finger on the Bartely, and the Fire is no longer seen, nor the Sound heard, — Again, I take off my Finger, and the Flashings appear, and the Tinkling of the Bells return as before.

Euphros. On my Word, *Cleonicus*, if you were to shew these Experiments in some Countries, with a black Rod in your Hand, and a three-corner'd Cap, and a rusty furred Gown on, they would certainly take you for a Conjuror, and believe you had the Art of dealing with the Devil, beyond even *Sydrophel* himself; for they could not possibly believe such Things were to be done by the Power of Nature, as you now shew by this small Machine.

Cleon. I don't know but what you say may be true enough. It is one of the miserable Effects of Ignorance, to be amazed at every Thing that is not common, and to wonder at Nothing that is. Every wise Man knows, that the Powers of Nature proceed from, and are established by a Being, all-powerful, and infinitely good; but ignorant People absurdly imagine, that some Things are above the Power of Nature, that is, of God himself, and therefore must be performed by the Devil, and his supposed Agents here. But those Notions, as they are equally absurd, ridiculous, and impious, can only be entertained by People devoid of Reason on the one Hand, and pretended to by Knaves and Villains on the other. — But to return, I must shew you a few more Experiments to make you still more acquainted with the Nature of this wonderful Power, one of which shall conclude the present Hour, and the other be deferred to another Time.

This Experiment, my *Euphrosyne*, will farther convince you, that Electricity is Fire; for it will actually kindle the Spirits of Wine, and set fire to Gun-powder itself, as well as the common Match; as you may inoffensively be convinced of by Experiment.

Euphros. You still talk of terrible Things. If these Kind of Firings are to be made by Experiment, I must beg of you to perform them yourself; it will be sufficient for me to have Presence of Mind enough to see them only; for I have no Notion of this Kind of electrical Fire-arms.

Cleon.

Cleon. Don't put yourself into any Consternation; they cannot do any Harm to you, or me, as we have now found, by Experience, a very innocent Method of setting fire to the Spirit, or Powder, without so much as a Shock.

Euphras. Pray, let me know your Method of Proceedure before-hand, that I may be a little upon my Guard, in Case there should be Occasion.

Cleon. There have been usually two Methods of producing this Effect: The first is as follows. — From the End of the electrified Gun-barrel, let a brass Ball be suspended by a small Chain, four or five Inches long; then while the Globe is in Motion, some heated Spirit in a Spoon is held under the Ball, very near it; the rising Fume is set on Fire by the Spark coming out of the Ball. This has been called the firing of Spirit by the *attractive Power* of Electricity. — The second Method is, by fitting the Handle of a Spoon, or Ladle, into the hollow End of the Gun-barrel, and the heated Spirit put in, and thus electrified, and then a Person not electrified, applying his Finger near to the Spoon, the Spirit will be fired from the Flame arising from the electric Explosion between the Spirit and Finger; and in this Case, it is said to be fired by the *repulsive Power* of Electricity. This Method of firing Spirits is also otherwise performed thus. A Person stands on a Cake of Bees-wax, or Rosin, holding a Chain from the charged Phial in one Hand, and a Spoon with heated Spirit in the other; then any non-electric Person, approaching his Finger near the Fluid, sets it on Fire as before. In the same Manner, if instead of Spirit of Wine, some Gun-powder be taken, and placed in the Spoon, mixed with a little Camphor, and then heated, the Fumes arising from the Camphor, will be fired, and communicate that Fire to the Powder, which will then flash away, without any Explosion; but in these Methods of Accension, the Persons concerned suffer the usual Shock; but Experience has taught us a more easy Way of producing the same Effect, and which you yourself might try as inoffensively, as you can apply your Finger to common Water.

Euphras. I shall take your Word for that; and beg to be a Spectator only in all Cases, where Fire is concerned; as you

know it to be so easy, you will oblige me with the Experiment yourself.

Cleon. That I will readily do, and shall premise to you one Experiment, by Way of Introduction. — You observe this Piece of Iron-wire, bent in the Form of a Curve, with a brass Ball at each End. — Also you will remember, that I observed to you, the electrical Fluid, when it proceeds from the Barrel, takes a Circuit to it again, by the nearest Way it can. — If, therefore, I apply one Ball of the Wire to the charged Phial, the Fluid will circulate, or be conveyed thro' the Wire to the Barrel again, without touching me that holds it, the Wire being the shortest Way, — and the Flash of Light this Way, you observe, so great, as to resemble Lightening itself. — Therefore, I take the Spoon, with the heated Spirit, and place it in the End of the Barrel. — Then I bring the charged Phial near to the End, and placing one Ball of the Wire against the Phial, and approaching the other towards the Spirit, — you observe, a great Flash, attended with an Explosion, which kindles the Spirit, without having the least Effect on myself.

Euphros. A surprizing Effect this, indeed! The Explosion was so fierce and loud, that it really made me leap; and innocent as it may be in itself, it will still make me unwilling to experiment it, by Reason of its very sudden and fierce Effect. — Pray, let me ask you one Question. Have not any of you Philosophers thought of a Method of making this electrical Fire subservient to any Purposes in the Art of War? For, if you could set Fire to Powder, 'as easy as you do to Spirits, would it not supply the Place of Locks to your Guns?

Cleon. The Question you ask is very pertinent; and Ways might be found, by Means of a Phial and glass Tube only, of discharging Guns and Cannon in the Field of Battle; but Nothing will prove so convenient as the Fire-lock and the Match: However, there is a Pleasure in knowing what may be done, tho' it may not always be the best Method for Practice.

DIALOGUE VII.

The Experiments on ELECTRICITY continued.

Euphrosyne.

I Long'd for the Return of this Evening, when you promised to shew me the very Essence, as it were, of Electricity itself, Pray, in what Manner do you propose to proceed in demonstrating this?

Cleon. For this Purpose, my *Euphrosyne*, it will be necessary, first of all, to make a *Vacuum*, by taking the Air from under a tall Glass-Receiver, placed on an Air-Pump, which, you see, I have here provided for this Intention. On the Top of the Receiver, you observe, a Cork sealed on with Wax, thro' which goes an Iron-wire, about 3 or 4 Inches below the Cork, and turned in the Form of a Ring, on the Outside above it. To this, the Chain, which comes from the charged Phial, is hung, and conveys the Electricity to the *Vacuum* within the Glass, which, when the Window-shutters are close, will be evident enough to your Sight.

Euphros. I am impatient to see this Experiment.——I have shut up the Windows, and made the Room dark.——The Chain is hung on the Glass.——And now, *Cleonicus*, let the Boy turn the Wheel, while I attend to view the Effect.——But Heavens! What do I see?——Not Fire of the common Sort, but somewhat, like Milk or Cream, descending in a copious Stream from the Point of the Wire.——It fills the whole Glass, but with a surprizing Kind of material Light, which I can scarcely call Fire.——It is quite different in Quantity, Quality, and every other Circumstance, in which it appeared to me before.

Cleon. This plainly shews, that the Matter of Electricity is not that very fine, or subtle, ætherial Medium, as many are fond of supposing it to be.——It appears very plainly of a thick, gross Sort of Matter, of a fluid Nature, and is rendered luminous by a *Vacuum*, and Want of common Light.——That it is the real Matter of Electricity is evident, by laying my Finger on the Barrel; for then it runs all off on myself, and you observe it no longer

longer in the Receiver. — When I take off my Finger, it rushes again from the Wire into the Receiver, and fills it with a luminous Fluid. — The Light, however, is but very weak, as it is not perceptible in common Day-light. — It also depends upon a *Vacuum*, or Air extremely rarified; for if I let the Air into the Receiver, it makes little or no Appearance, even in the Dark, as you observe.

Euphros. All these Particulars I cannot but see with the highest Satisfaction, as they convey fresh Ideas to the Mind of such Things as I could never otherways have known. Indeed! in this View of it, it appears of a very gross Consistence, as if it were Particles of Fire, Air, Sulphur, and other Parts of Bodies, mixed together, in one luminous Fluid. Pray, what have I further to observe peculiar to this Matter?

Cleon. One Thing is very extraordinary; viz. that, where-as all Objects appeared coloured, when viewed through a Prism in common Light, the Light of Electricity affords no Colours at all. — For your own Satisfaction, take this Prism, and view it.

Euphros. I will. — It appears to me no otherwise thro' the Prism than without. — I see nothing of any different Colours of Light, and am fully satisfied, as to this Particular. — Have I any further Use of the Prism?

Cleon. No; but there is another Method of shewing this Phænomenon still in greater Perfection, by making a more perfect *Vacuum* than can be made by the Air-pump; the Apparatus of which I shall now proceed to describe to you, having first opened the Windows, that you may see it. — On this tall Frame of Wood, you observe two Cups of Glass, partly filled with *Mercury*, in which are immerfed the two Ends of a long incurvated Glass-tube, in each Part whereof, the Quicksilver rises, above that in the Bason, to the Height of about 30 Inches; and all the internal Part of the Tube, above the Quicksilver, is a *Vacuum*, or a Space, as void of Air, as can be made, perhaps, by Art. The Manner of making which, you will be hereafter more particularly taught; at present, I move the electrical Machine to the Side of the Room, under the Frame, and you will find, when it is darkened, how surprizingly perfect both the Matter and Motion of Electricity will appear.

Euphros.

Euphros. Then I will put the Window-shutters close, for I long to see the curious Phenomenon you speak of. — The Room is now dark; therefore, haste, *Cleonicus*, and shew the wondrous Spectacle.

Cleon. I am ready. — I lay a Wire from the Barrel to the *Mercury*, in one of the Glasses, which conducts the Electricity to the Tube. — The Globe is whirl'd round, and behold! How quick the Lightening flies from the *Mercury* into the *Vacuum* of the Tube? — In that, how strong, how vivid, how sensibly, and how quick it moves through that long Space of the Tube! — Ascending in one Part, running over the Top, and down the other Leg of the Tube, in an apparent Rivulet of Fire. — When I put my Finger on the Barrel, to intercept the Fluid, it flows no longer in the Tube. — My Finger removed, the Torrent of Fire rushes on, as before, with an unequal, undulating Kind of Motion.

Euphros. Such a wonderful Appearance of electrical Fire, or rather of a luminous Fluid, exceeds every Thing I could have thought, or expected; the Motion of it is unspeakably quick, and yet sensible at the same Time. I presume, it appears thus in the Tube, as being confined in Glass, transmitted first from the *Mercury* on one Side to the *Vacuum*, and from thence to the *Mercury* on the other, from which it is dissipated insensibly into the surrounding Air.

Cleon. You judge very rightly, Sister. Nothing but a Glass, or other electric Tube, could confine the electric Fluid; but the Velocity of Motion in this Experiment you cannot really observe. That is too great to be sensible at the Distance of many Miles, as has been found by repeated Experiments made with an electrical Machine on the Top of *Shooter's-hill*, and a Chain-Conductor, suspended by silken Strings, on the Road on either Side of the Hill, from one End to the other, more than 2 Miles. The Token was given by firing of a Gun, but the Electricity was found at the End of the Chain, as soon as the Light from the Fire; and, indeed, it is a Question with many judicious People, if there be much Difference between the Velocity of Electricity, and that of Light itself; and, therefore were a Chain suspended round the Globe of the Earth, the Time which

which the electrical Fluid would take to run through it, would probably be altogether imperceptible.

Euphras. Well ! These are unaccountable Facts to me ; but does not all these Appearances incline People to believe, that there is a great Similitude between Electricity and Lightening ? It would appear to me to be almost the same Thing ; but that the Force of Lightening is so much superior in its Effects to that of Electricity ; for Lightening will kill a Man, rend Trees, and melt Metals ; but I have heard Nothing more of Electricity, than of its killing a small Bird, and the like.

Cleon. Because you have not yet been told of the greatest Effects of Electricity, which has killed a MAN, as effectually as a Bird.

Euphras. Indeed ! Pray, how did this terrible Catastrophe happen ?

Cleon. I will give you a short Account of it. ——— After observing the Phænomena of Electricity, People were soon induced to enquire what Relation there was between that and Lightening, and to imagine, that what they had observed of positive and negative Electricity, among several Bodies on the Surface of the Earth, might likewise obtain, in some Measure, between the Clouds in the Heavens, *i. e.* the Clouds might be electrified some of them positively, and others negatively ; so that those which are charged with a greater Quantity of this electrical Matter would, upon meeting with others that contained a less, discharge their Overplus with so much Violence and Explosion, as to cause the Lightening and Thunder which we see and hear. From hence they concluded, there was great Reason to suppose, that the Air was filled with this electrical Fluid, and that of Course, they could contrive to find by Experiment the Reality of such a Thing. The flying of a Kite was looked upon as the best Expedient for this Purpose, which accordingly was tried by several Gentlemen Abroad with great Success ; for instead of holding the long Line by a Packthread, as usual, they tied on 2 or three Yards of a silken String near the End, which they held in their Hands. This prevented the Electricity from coming to the Person who directed the Kite. At the Place where the Silk was tied on to the Hempen-cord, there descend-

which the electrical Fluid would take to run through it, would probably be altogether impracticable.

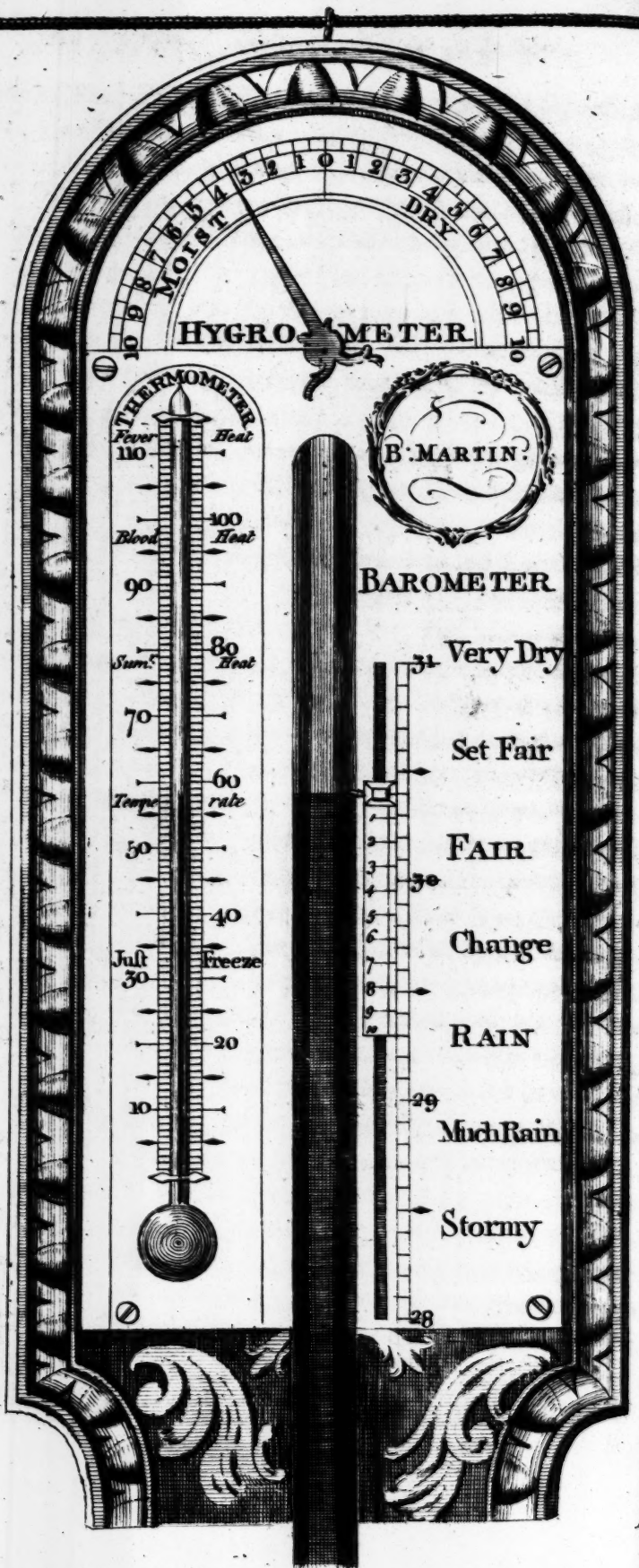
Exphry. Well! These are unaccountable Facts to me; but does not all these Appearances incline People to believe, that there is a great Similitude between Electricity and Lightning? It would appear to me to be almost the same Thing; but that the Force of Lightning is so much superior in its Effects to that of Electricity; for Lightning will kill a Man, rend Trees, and melt Metals; but I have heard Nothing more of Electricity, than of its killing a small Bird, and the like.

Clara. Because you have not yet been told of the greatest Effects of Electricity, which has killed a Man, as effectually as a Bird.

Exphry. Indeed, Pray, how did this terrible Catastrophe happen?

Clara. I will give you a short Account of it. — When observing the Phenomena of Electricity, People were soon directed to enquire what Relation there was between that Lightning, and to what they had observed of positive and negative electrical Bodies on the surface of the earth, might be obtained, in some Manner, upon the Clouds in the Atmosphere; and others negatively electrified, some of them positively, and others negatively electrified, which are charged with a greater Quantity of the electrical Matter, when meeting with others that contain a less, discharge themselves with much Violence and Noise. When hence they considered, there was great Reason to suppose, that the Air was filled with this electrical Fluid, and that of Course, they could contrive to find by Experiment the Reality of such a Thing. The flying of a Kite was looked upon as the best Experiment for this Purpose, which accordingly was tried by several Gentlemen Abroad with great Success; for instead of holding the long Line by a Packthread, as usual, they tied on a or three Yards of a linnen string near the Hand, which they held in their Hands. This prevented the Electricity from coming to the Person who directed the Kite. At the Place where the Silk was tied on to the Hoop-cord, there being

I B. ROBERTSON M. A. G. N. U. M.
 or,



ed a Packthread-string, with the same Phial at the End of it, usually applied to the Gun-barrel; now, by this Means, it was certain, as the Kite was a non-electric Body, and the String by which it was flown, they would certainly convey the Electricity in the Air to the Phial, which would be found by applying the Finger, or any other Object to it, as usual. Which accordingly succeeded, and at some Times to almost a dangerous Degree.

Euphros. Well! this was carrying the Thing to a great Height indeed! The Story of *Prometheus's* stealing Fire from Heaven was but a well-known Fable; but the modern Philosophers have, it seems, realized it. They make nothing to deprive *Jove* of his Artillery, and that which was thought to be a Miracle in *Elisha's* Time, is now but the common Amusement of the *Virtuosi*. — They not only call Fire from Heaven; but take it without asking, whenever they please. — Such Exploits far exceed any Thing Antiquity has to boast of. — I should be extremely afraid to try any of these celestial Experiments; but yet, methinks! I long to see something of the Nature and Manner of it.

Gleoni. I will take care to gratify you in this Respect very soon, by taking you to a Gentleman's House, who has a proper Apparatus for that Purpose, and will be extremely pleased with an Opportunity to satisfy your Curiosity, in the most entertaining, and innocent Manner. Thro' an open Window, in the uppermost Room of his House, a large Pole is suspended on silken Strings within the Room, and duly balanced; so that a tall, iron Rod, fixed in the extreme Part without, and ascending above the Height of the House, shall not be able by the Force of Wind, or otherwise, to turn the Pole about. From the inmost End of this Pole, a Chain, on silken Strings, is carried down the Stairs to the lowermost Part of the House, where is placed the usual Apparatus of electrical Instruments. As the Iron-rod on the outmost End of the Pole is the highest Object in the Air, the electrical Fluid, when it abounds in the Clouds, and in the Air, will naturally flow to the Top of the Rod; from thence be conducted to the Apparatus below, where the Phial communicates the Electricity by a Snap. — Where you will see the Leaf-gold, and other light Bodies, attracted and repelled. —

You will also hear the Bells ring on a sudden, as if by Enchantment; and by Means of two very light Balls, suspended by flaxen Threads, you will see his curious Method of knowing whether the Electricity is from a Cloud, electrified positively, or negatively: — And whether it be ascending into the Air, or descending thence to the Earth. — These Things may possibly salute your Eyes and Ears, at the same Time you are sitting with him at the Tea-Table.

Euphros. Nothing would be so agreeable to me as such a Piece of Scenery as this. — How poor and low must all vulgar Amusements be, when compared to this! — One would think such a Gentleman would have all the World to visit him; for my own Part, I should think it an Entertainment for Angels, rather than for Men. — I am amazed, when I think every Gentleman of Fortune has not such an Apparatus in his House.

Cleon. It is not so much to be wondered at as you imagine. 'Tis easy to assign several Reasons why they have not. — The first is, that every Gentleman's House is not properly situated for this Purpose; for such a House ought to be the highest in the Place, or distant from any other. Secondly, such an extraordinary Entertainment would lay him under an Obligation (as you observe) of having more of his Neighbours Company than he would at all Times chuse. And lastly, another Reason is, that Gentlemen of Fortune have not always the Felicity of a Philosophical Taste; tho' the Expence, or Trouble of erecting such an Apparatus would be next to Nothing, when compared with the Sums of Money they other-ways expend to no Purpose. We live too late in the Day for any Enterprizes of this Kind. Had this Thing been known 50 Years ago, there had then been doubtless fifty of these Apparatuses to one we find now.

Euphros. I fear there is but too much Truth in what you say. — But I'm impatient to hear more of the Fate of that Philosopher, whom you just now said was killed by this Fire from Heaven. Pray, what was his Name, and how was it brought about?

Cleon. This unhappy Person was the ingenious and industrious Professor *Rickman*, at *Petersburgh*, who lost his Life by an electrical

electrical Stroke, or Shock, on the 6th of *August*, 1753; as he was observing, with *Mr. Sokolow*, (Engraver to the Royal Academy there) the Effects of Electricity upon his *Gnomon*, or *Electrometer*, during a Thunder-storm. *Mr. Sokolow* saw a Globe of blue Fire, as big as his Fist, jump from the Rod of the Apparatus towards the Forehead of Professor *Richman*, which was at that Instant about a Foot distant from the Rod. It was attended with a Report, as loud as that of a Pistol; and he fell down instantly dead. His Apparatus was perfectly insulated (or suspended) by silken Strings, and had no Communication with the Earth; by which Means, the great Quantity of electrical Fluid, with which the Apparatus was replete, from the Vastness of the Cause, discharged itself thro' the Professor's Body, being the nearest non-electric Body in Contact with the Floor; and this was unfortunately the Cause of his Death.

Euphros. It chills my Blood, to hear of so disastrous an Accident! ——— Now you tell me this, I shall be afraid to be in the House where such an Apparatus is found. I must beg you to excuse my Visit to the Gentleman you proposed. ——— I am all over Horror at the Thoughts of it.

Cleon. You need not terrify yourself to that Degree. Such Disasters happen from our not being acquainted with the Force of natural Powers; but when we do know them, we can easily elude them. You know the old Saying *Happy are they whom other Folk's Harms make wary*. We know the Rock on which he split; and, therefore, can steer a different Course, in trying these Experiments. We can chuse whether we will let the Electricity go thro' our Bodies or not; we can try its utmost Force without feeling any of its Effects ourselves.

Euphros. You have related to me some of the dreadful, and deadly Effects of Electricity; pray, do you know of no salutary, or beneficial Consequences of its Application? I think, I have heard it mentioned as a medicinal Expedient in many Disorders, incident to human Nature; pray, what do you know certainly of it in that Character?

Cleon. Like yourself, I have heard of many great Effects, and Cures performed by it. ——— It has been reported, that Electricity has made the Lame to walk, the Blind to see, and the Deaf to hear; that it has cured Rheumatisms, Palsies,

Spasmodic Contortions, and what not; ——— but how far these Things have been true, I cannot take upon me to say, having never been an Eye-witness to any Cure done by it. ——— There is good Reason, however to believe, from the undoubted Testimony of others, that many considerable Effects in Medicine and Surgery have been produced by it. * One Gentleman in particular has published a large Account of Cures performed this Way, and some of them very extraordinary. ——— One Thing is worth observing, that a new Method of practising Physic, by a Kind of *electrical Inspiration*, has proved, upon Trial, unsuccessful, to the great Disappointment and Mortification of the *Beau Monde*. For still, alas! the Beaus and Belles are obliged to have Recourse to the grosser Methods of Evacuation, by Doses, as other Folk do. And now, my *Euphrosyne*, I think, I have pretty well done with the Subject of Electricity; having shewn you such Experiments as I judged most proper to give you an Idea of the Nature, and Genius of this strange and surprizing Power. There are innumerable others, with which you may entertain yourself, either by reading, or practising of them on the Machine, as you think proper, at your Leisure Hours: What further may be done in Electricity, must be left to the Discovery of future Experiments. In this Case, as in all others, People are extremely apt to run into Extremes, and pretend to a great deal more than they have any Grounds, or Reasons for: Thus, many have vainly imagined, that the whole Solar System is kept in Motion by Electricity. ——— This Fluid, they are very positive, is the same with the subtle Spirit which Sir *Isaac Newton* has often mentioned; and which is mightily talked of by our modern *Virtuosi*, and as little understood. ——— Others make no Scruple of accounting for almost every Thing they see in Nature by it. They find an electrical Machine a much easier Introduction to Philosophy than *Euclid's Elements*, or the *Newtonian Principia*. ——— In short, they have happily found out an easy, and cheap Method of being wond'rous wise, and doing as much in half a Year, as *Newton* himself in half a Century. But we will leave this Species of Philosophers to their own Delusions, and Dotage; and, in the next Place, if it be agreeable to you, we shall proceed in our Speculations on other

* Mr. Lovet, of Worcester.

other Properties of the Air, and the Description of such Instruments as are proper to explain them.

DIALOGUE VIII.

Of the Nature, Construction, and Use of the
BAROMETER.

Euphrosyne.

AS I am engaged to spend the Evening abroad, I shall be glad to attend your philosophical Explications this Morning, Cleonicus, if it suits you.

Cleon. Nothing can be more agreeable. The Morning is the prime Time of the Day for such Purposes; but Business, which is the Basis of Life, obliges us to apply it other ways, and Leisure only recommends the Evening, when something seems wanting to recruit and exhilarate the Spirits, languishing with the Labour of the Day. Hence those incredible Numbers we every Night observe crouding the Theatres of Plays, Operas, and Oratorios, for a few Hours Amusement to the Senses; and those, generally speaking, low enough too; while few attend to Lessons on the Sciences, and the noble Researches of Philosophy. — The Morning is fine, and we shall, with Pleasure, see what we are about. I shall therefore, take this Opportunity to explain to you some of the most observable Properties of the Air, which yet remain to be considered, how far we may reduce them to Use in real Life, and exemplify the same by proper Instruments and Experiments.

Euphros. This will afford me the highest Pleasure. But; what are we to begin with first?

Cleon. The WEIGHT of the Air is the most important Property thereof, every Way considered. The whole Frame, and State of Nature are interested in it; and particularly the Life and Health of Animals, and Plants. Then the variable HEAT and COLD of the Air will command our Regard on many Accounts; and, in the last Place, we shall find it our Interest to
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advert on the different Degrees of the MOISTURE and DRYNESS of the Air. The Weight of the Air we shall illustrate by the BAROMETER; the Heat and Cold by the THERMOMETER; and the Moisture and Dryness by the HYGROMETER.

Euphros. In what particular Cases does the Weight of the Air most affect us?

Cleon. By its very considerable Pressure on the System of Animal Fibres, it gives them their proper Tension or Tone; or, to use the Physician's Phrase, it braces up the Fibres to the Standard of Nature, so that their Actions on the Fluids are exerted with such a Degree of Force, as to cause a due Circulation of the Fluids. In short, the Weight of the Air, in the Animal Economy, is like the Weight of a Clock in Mechanics, which gives Motion to all the Machinery, and is the regulating Principle of the whole. Moreover, the Air, by its Pressure, rushes into the Lungs of all Animals, sets those noble Ventilators to Work, communicating, by that Means, a vital Principle to the Blood, which flows through it in the fresh, and wholesome Air that we breathe in, in constant Respiration. — In like Manner, we find the Air is every Way necessary for Vegetation; the Bodies of Plants, as well as Animals, are properly organized to circulate this necessary Fluid; and, by some Experiments, we shall see hereafter, it will appear, that they respire great Quantities of Air.

Euphros. If this be the Case, and our Life, as well as our Health, depends so entirely on the Weight of the Air, I think it behoves every one to get the best Information of this great Principle that he possibly can. Pray, what Methods do you take to make it most easily known to Mankind?

Cleon. The Experiments of the Air-Pump are best adapted for this Purpose. They shew the universal Necessity of this Wind; but the *Barometer* is that Instrument alone, which measures the Weight of the Air, and consequently, will give the most adequate Idea thereof to your Mind. This will shew you its gradual Increase and Decrease of it at different Times, by which we may, in a great Measure, judge of the salubrious State of the Air; for by this, we can see when the Weight of the Air is greatest, and, consequently, most conducive to our Health; also, when it is least of all, and therefore to be upon our Guard against
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any Inconveniencies that may arise from thence; which oftentimes affect not only our Health, but our Fortunes also.

Euphros. Pray, what do you mean by Fortunes, in Regard to the *Barometer*? Is that any Measure of our good or ill Success in Life? Does our Riches or Poverty in any Measure depend on the Heaviness or Lightness of the Air, *Cleonicus*?

Cleon. I can assure you, my *Euphrosyne*, that it is a Matter of more than meer Pleasantry, and whether People think of it or not, it is certain, they are richer or poorer for being more or less prudent in their Conduct in Life; and, therefore, since the *Barometer* most certainly indicates the State of the Air, in Respect to its Weight, it follows, that it must likewise, at the same Time, shew us, not only the present Circumstances of the *Weather*, but also prognosticate the future Changes that may immediately happen; and on such Fore-knowledge you will readily allow, a great deal must depend. If a Journey on Land be intended, a wise Man would consult his Weather-glass; and is thereby prepared to avoid the Rain and bad Weather which might, probably, have occasioned his catching Cold, the too general Cause of an ill State of Health, and oftentimes the Loss of Life. ——— If you were to go by Sea, and there be any Hurricanes or Storms depending, the *Barometer* proves a faithful Monitor, and gives you previous Notice of the same. ———

Lastly, in Regard to the Business of Husbandry; a Person, possessed of a *Barometer*, knows the proper Season for applying the Sickle or Scythe; when the ignorant Farmer cuts down his Corn and his Hay improvidently, and leaves them to macerate and spoil in the soaking Showers that fall.

Euphros. If the *Barometer* be of such mighty Consequence as you represent, it is surprizing to me, that every Man in the Kingdom has not one of them in his House. Who would, for the sake of such a small Sum of Money, want a general Index for Life, Health, and good Fortune?

Cleon. There are few People but what have a Weather-glass of one Kind or other, they are so sensible of the Benefit of it in general; but it is in this Case as in many others, if they get but an Instrument with a Name to it, and for a very little Money, they are satisfied; not regarding the Truth, or intrinsic Value of a good Construction.

Euphros.

Euphras. By what you say, there are different Sorts of *Barometers*; I should be glad to know how they are made, and what different Kinds of them are in Use.

Cleon. I shall first shew you the Manner of making one of the best Sort, and then point out the Forms and Deficiencies of the Rest. — I have here provided you with what we may properly call a *triple Weather-glass*, consisting of a *Barometer* of the best Sort, a *Thermometer*, and a *Hygrometer*, all in one Frame, by which the State of the Weather, in all the above-mentioned Respects, may be seen at one View. — Here it is.

Euphras. The Instrument appears not less elegant than useful! It makes a Piece of ornamental Furniture for a Gentleman's ParLOUR, or Study; and, I think, the most so of any one Thing I know of the Philosophical Kind. The large Tube in the Middle is the *Barometer*, I see; and you may now, if you please, let me know your Method of filling it with Quick-silver, and likewise explain to me how that proves the Measure and the Weight of the Air.

Cleon. That I shall instantly do, in such a Manner, that you, or any one else, may practise it with Pleasure afterwards. Thus — the first Thing to be done is, to take this Phial of Mercury (which is about one Pound and a Quarter, made very pure for this Purpose) and to heat it by the Fire; — then, this Glass-tube, which is now empty and very clean, is to be heated by the Fire likewise; and then rubbed pretty briskly with a Piece of Leather, or Cloth, just before the Mercury is poured in. — In the next Place, this little, Paper-funnel, with the small Hole in it, is necessary to convey the Quick-silver in a fine Stream to the Tube, filling it by slow Degrees: — All which you see me now perform.

Euphras. And a very pretty Sight it is, to see the Quick-silver trickle down the Tube. — But I observe, as the Quick-silver rises in the Tube, there are Bubbles of Air in several Parts of it left behind. Pray, how do you get them out, when the Tube is filled?

Cleon. There are several Methods by which this may be done, but the best is as follows — I continue pouring in the Quick-silver 'till it fills the Tube within an Inch of the Top; then setting

setting down the Phial, I apply my Finger, hard and close, upon the Top of the Tube, and then invert it; by which Means, you see, the Air, which was on the Top, now rising thro' all the Quick-silver, gathers every Bubble in its Way; then I revert the Tube, or turn it up again; the Bubble of Air now re-ascends, and if any small Bubbles remain, they are now taken quite away, and the whole Body of the Quick-silver is left entire. ——— Look narrowly at it, and tell me if you can perceive one single Bubble of Air.

Euphros. Not one. ——— It is quite pure, and beautifully black, like Jet. ——— Pray, what do you next?

Cleon. I take the Phial, and fill the Tube to the Top. ——— Then, I pour the Remainder of the Quick-silver into this Teadish; and putting my Finger fast on the Top of the Tube, I once more invert it, and put my Finger, with the End of the Tube, under the Quick-silver in the Cup; ——— then, withdrawing my Finger gently from the Tube, so that the Mercury in the Tube and Cup may readily unite, without a Particle of Air getting in. ——— And now you see the Silver subside, or sink down from the Top to its necessary Height.

Euphros. Very good, it does so. But why does it not sink lower, *Cleonicus*?

Cleon. It can sink no lower; because the Air will support so much in the Tube as is equal to its own Weight, upon the same Base, with that of the Quick-silver; for when two Fluids mutually press upon each other, they will always keep moving, 'till they come to an Equilibrium, or where the Weight is on each Side equal, and then they must necessarily sustain each other at rest.

Euphros. I remember you told me, that the Weight of the Air upon a square Inch was equal to about 15 Pounds, and by this Experiment, I suppose, if the Tube was of a square Form, and the Bore of it equal to a square Inch, if it was filled with Quick-silver and inverted (like this small one) in a proper Quantity of Mercury, the Mercury then would subside to the same Height with this, and the square Column, supported, would weigh about 15 Pounds: Am I right so far, *Cleonicus*?

Cleon. Very right, indeed. ——— As by this Experiment, you see the Weight of the Mercury in the Tube is always of

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an equal Weight with a Column of Air, of the same Base, and of the Height of the Atmosphere; so it must consequently be an adequate Measure, at all Times, of the Weight of the Air; and in this Manner, you see, the Barometer-tube is placed in the Mercury, in the Basen at the Bottom of the Frame in the Weather-glass.

Euphros. I do. — But, why is it necessary to have so large a Quantity of Mercury in that Basen?

Cleon. The Quantity is not so large as you imagine from its Surface. — It is but shallow, tho' the Surface be wide; for was the Surface not very large indeed, it would, in some Measure, rise and fall with that of the Mercury in the Tube, which ought by no Means to be; for the Height of the Mercury in the Tube is always measured from the Surface of that in the Basen, and therefore, unless the Latter was always to continue the same, the Variations of the Former could never be duly estimated.

Euphros. I fully comprehend your Meaning in this Respect. — What else is necessary to the Perfection of this Instrument?

Cleon. The Size of the Bore, which ought to be never less than two Tenths of an Inch, nor need it be more than four; in Tubes of a small Bore, there is a sensible Force of Attraction from the Sides of the Tube, which prevents the free Motion of the Quick-silver in it, and in such Cases, no Alteration in the Weight of the Air can be seen, 'till it is great enough to overcome that Force of Attraction in the Tube, and therefore, those Weather-glasses, which are made with small Tubes, hold but a little Quick-silver, and come very cheap; but are, at the same Time, good for little or nothing to the Purchaser; whereas, on the contrary, in the Tubes which are large, and will hold near a Pound of Quick-silver, the Weight of it will render it independent of the Attraction of the Tube; its Motion will always be free, and it will shew the very first, and most immediate Alteration in the Weight of the Air, and, in short, no other *Barometer*, than what I have now described, will do this, and consequently, this, as it is the most simple, so it is the best Form of any.

Euphros.

Euphros. You have convinced me very rationally, that this must be the best Form of a Barometer. But why, then, is there such a Variety of other Forms of this Instrument, if this be the best of all? For I remember, upon a Visit the other Day, I saw two Barometers in the Gentleman's Parlour, of a very different Form from this; one of them had three glass Tubes, bent almost horizontally towards the Top, and disposed between several rich silvered Plates, with curious Engraving, and a charming gilt Frame; I think he said, it cost him six or seven Guineas.

—— The other, consisted of a very long Tube, bent at the Bottom, and turned up again to the Top of the Frame; the first Part, I observed, was filled with Quick-silver, the other, with a Sort of blue Liquor, but what, I don't know. —— Pray, why do Gentlemen chuse these other Forms?

Gleon. Several Reasons may be assigned for it. —— First, every Gentleman that wants a Barometer cannot be supposed to know which is the best Form: When they apply to the Shops, they are very gravely, and *honestly* persuaded to buy that Sort which the Shop-keeper has at Hand, and which his Profits are largest upon. —— In the second Place, they are also told, that the Motion of the Quick-silver (or other Fluid) is five or six Times as great in those of a bent, or diagonal Form, as in the simple, upright one, and they immediately conclude, that they must be so much better of Course. —— A third Reason for such a bad Choice is, that many Gentlemen, as well as Ladies, affect to have Things very fine and showy, and such as shall make a grand Appearance. —— And to mention no other Reasons, unless an Instrument be costly, one Sort of Buyers will have no great Opinion of them, and the Retailer will find it, very often, a difficult Matter to dispose of his Goods to these Sort of People, without a magnificent Price.

Euphros. But all you have now said falls short of the Satisfaction I expected. —— I imagine, when People buy such Things, they have a greater Regard to Use than Decoration, and would always be fond of that which was best in its Kind; to which People of Fortune might annex as splendid an Apparatus as they please. —— But if the Scale of Motion for the Quick-silver, in the compound, diagonal Barometer, be so great, as to amount to no less than 40 or 50 Inches in Length (as you hint

ed just now), and in that which you recommend the Scale is limited to three, I profess I am one of them that cannot readily see why those should not be preferable to this.

Cleon. The Reason why you do not, is, because you have not considered, that the principal, and critical Use of a Barometer is to shew the *first Alteration* in the Weight of the Air, which ought to be known for the more early and certain Prognostics of the Weather, and for being the more duly prepared for the Consequences of it. — A Telescope, that would not shew the Moments of the Beginning or End of an Eclipse, ought not to be called an *astronomical one*, or thought, by any Means, perfect in its Kind; a common Telescope, or a Bucket of Water, will serve incurious People for viewing an Eclipse; and so any Sort of Barometer will suffice for shewing the Alteration of the Air, when it has already happened. The long Scale is only a vulgar Error; there are better Methods contrived to answer the same Purpose, in a simple Barometer, for such as have Ingenuity enough to use them; I mean, a common Understanding only; for little more is required to be Masters of the nicest Parts of this Art, when we get into a right Way of thinking about it.

Euphros. I am not satisfied yet; tho' there may be great Truth in all you have said. — You have not yet told me why a Barometer of a large Scale will not shew the first Variation of the Weight of the Air, as well as this of a small one.

Cleon. Well; you have brought me to the Point, and I will now declare the Reason to you. — The Mercury, in those large Scales, does not rest, or depend on the Air alone, but on the Tube in which it is contained, and the longer the diagonal, or bended Part of the Barometer is, and the greater their Number, the more will the Quick-silver rest on the Tube, and the greater, of Course, will be the Impediment of its Motion; for it is here considered, as a Body moving up and down an inclined Plane, and then the Resistance that is given to such Bodies, considered mechanically, joined with what results from the natural Cohesion between the Quick-silver and Glass, must prove a considerable Obstruction to its Motion; and, 'till the Weight of the Air be so far altered as to overcome those resisting Forces, the Motion of the Quick-silver cannot begin, and therefore it must be considerably after the Time that it commences Motion

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in the upright, simple Barometer. ——— When I have shewn you some Experiments in Mechanics you will be better able to understand the Reason, and Truth of what I now tell you; at present it will not be worth while to spend more Time in shewing how this Principle of Resistance, will ever lie as an insuperable Obstacle to the Perfection of any other Forms of Barometers. ——— The *Wheel-Barometer* has more Ingenuity than Exactness to recommend it. ——— And that Barometer, which a Gentleman has lately contrived to shew the Height of the Mercury for every Day in the Year, deserves very much to be admired for its Mechanism and Contrivance, but is too expensive, and liable to the Objection of *Inaccuracy* with the Rest of the compound Form.

Euphros. I see, you are determined to admit of no Construction of this Instrument, but what I here have; therefore, pray, let me know how I may render this short Scale equivalent to a large one, as you just now imply'd might be done.

Cleon. The Scale, at present, contains but three Inches, and each Inch is divided into ten equal Parts, which you see are visible enough to the Eye; therefore, the whole Scale contains thirty visible Parts. ——— How much further would you chuse to go?

Euphros. You may depend upon it, my Curiosity will carry me as far as I can possibly go, in that Respect; and you can best tell me, where I must stop.

Cleon. That I will do. You may have each of these 30 Parts divided into 10 others, by Means of a little Sliding-piece of Brass, whose Index upon the Top, points exactly to the Surface of the Quick-silver in the Tube; from this Index, it is divided into 10 equal Parts, which are just equal to 11 of those on the Scale. This little Artifice goes by the Name of a *Nonius* (being the Name of the Person who first published it to the World). As 10 Divisions on the *Nonius* exceeds 10 on the Scale by one whole Division; so one Division on the *Nonius* will exceed on the Scale by $\frac{1}{10}$; two, on the *Nonius*, will exceed two on the Scale, by $\frac{2}{10}$; three, by $\frac{3}{10}$, and so on; therefore, whenever you place the Index to the Surface of the Quick-silver, you will see what Divisions on the *Nonius* and the Scale coincide; and the Number on the *Nonius* shews how many Parts of Ten, the Index is above

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above the Division on the Scale, next below it, and so will shew, not only how many Inches, and Tenths of an Inch, the Quick-silver is high, but its Height, even to the Hundredth Part of an Inch exactly; and thus the Scale is divisible into 300 equal Parts, which is as far as the most scrupulous Philosopher can desire.

Euphros. All this may be true enough for ought I know; but unless you can explain it to me by an Example, you may as well tell the Story of your *Nonius* to my Linnet, as to me.

Cleon. I make no doubt but you will easily understand it by an Example or two, which you shall perform yourself, that you may be the more ready at it another Time.

Euphros. That pleases me well: ——— But, what am I to do first?

Cleon. Cast your Eye on the Barometer, and move the Index of the *Nonius* nicely to the Edge of the Quick-silver in the Tube.

Euphros. This I have done. ——— What is the next Thing to be observed?

Cleon. Look the Division on the Scale, that is next below the Index of the *Nonius*, and tell me what it is.

Euphros. I will look. ——— It is the second Division above 30; by which, I perceive, the Quick-silver is more than 30 Inches and $\frac{2}{10}$ of an Inch high.

Cleon. Very right; and now you are to tell me how much more, by observing what Divisions of the *Nonius* and Scale coincide, which you are next to see.

Euphros. I observe, the fourth Division upon the *Nonius* is just against the Division upon the Scale. ——— But what do I learn from thence?

Cleon. From thence it is apparent, that the Index is advanced four Parts out of Ten, from the second to the third Division of the Scale above 30. ——— And therefore, the whole put together amounts to this, that the Quick-silver in the Tube stands at the Height of 30 Inches $\frac{2}{10}$ of an Inch, and $\frac{4}{10}$ of another; that is, 30 Inches, and 240 Parts of another Inch, is the Height of the Quick-silver.

Euphros. Very good; I see by this plainly, that I can determine the Height or Motion of the Quick-silver to the hundredth

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Part of an Inch ; which I am sure will be sufficient for my Purpose ; and, I suppose, for any one's else. — Is there any Thing farther, in regard to Barometers, worth my Notice at this Time ?

Cleon. I could observe to you many other Circumstances, and Particulars, relative to Barometers, but I judge it would be Loss of Time, at present, as my only View in these Conferences with you, is to make you acquainted with that which is best, and most perfect in its Kind, among the Instruments used in every Art or Science. We shall therefore dismiss this Subject, and proceed to consider another Instrument, by which we explore the various Degrees of Heat and Cold in the Air, for the Subject of the next Leisure-hour which occurs.

DIALOGUE IX.

Of the Nature and Use of THERMOMETERS, and their Variety of different Constructions.

Euphrosyne.

I Have now an Opportunity, *Cleonicus*, of putting you in Mind of your Promise of explaining to me the Nature of the THERMOMETER, by which you measure the Degrees of Heat and Cold in the Air.

Cleon. No-body is more ready to fulfil Engagements of that Kind, than myself, and I shall embrace every Opportunity for that Purpose ; especially the present one. The Nature of the Thermometer is, undoubtedly, reckoned among the pleasantest Speculations in Philosophy. As the Design of this Instrument is to give us an Estimate of the Heat or Cold in the Air at all Times, it is evident, it must be of the utmost Consequence upon many Accounts ; since the Health, and consequently the Life, of Man is greatly affected by this Quality of the Air ; I need not give you Instances of the manifold Miseries, Diseases, and other Misfortunes that have happened to Mankind in every Age, from the Intemperature, and Extremity of Heat and

and Cold in the Air, and therefore, we cannot be too sufficiently instructed in all the proper Methods of guarding against them; and not only so, but the Vegetation of different Kinds of Plants and Trees depends upon a peculiar Degree of Warmth or Heat in the Air, Water, or Earth, in which they grow, and the *Thermometer* is found to be the principal Instrument for all such Purposes.

Euphros. As this is the Case, it will undoubtedly follow, that the Ingenuity of Men of a philosophic Turn, must have contriv'd and introduced many different Forms and Structures of this Instrument; I should be glad, therefore, to know what they are, and how many?

Cleon. I must observe to you, in the first Place, the Rationale of the Instrument in general, and then recount to you some of the best Methods of constructing a Scale for its Use. — In the first Place, therefore, you are to observe, that every Cause is best estimated or measured by the Effects which it produces, and since, in most Bodies, the Effect of Heat is an Increase of their Dimensions, therefore the variable Bulks, or Dimensions of Bodies, will be a proper Measure for this Purpose, and those, whose Dimensions are most of all increased, or diminished, by Heat or Cold, first offer themselves as the properest Subjects to answer this End, and since Fluids are much more subject to a Dilatation and Contraction of their Bulk, than solid Bodies, our first and last Essays of this Kind have been made with them.

Euphros. Among the different Kinds of Fluids, which have been mostly used for the Measures of Heat and Cold?

Cleon. The AIR is a Fluid, most of all apt to rarify with Heat, and be condensed with Cold, and would serve for the Medium of a *Thermometer* the best of any Thing in Nature, were it not that the same Effects are produced from other different Causes. According to the different Gravity of the Air it will occupy a greater or lesser Space, as well as from different Degrees of Heat and Cold, and so the Experiment of a *Thermometer* with Air, would become ambiguous, as it would be oftentimes doubtful, whether the Effect was owing to one, or the other Cause.

Euphros. And are there any Sort of Fluid Bodies which will be extended or contracted by Heat or Cold alone?

Cleon.

Cleon. Yes; every other Fluid but Air, as all others are destitute of a Spring, or Elasticity, and are incompressible from any Weight on their Surfaces, the Alteration, therefore, that they undergo in their Bulks must be from Heat and Cold alone; among these, *Water* expands and contracts the least of any, and therefore not so fit a Subject for a *Thermometer*; besides, it has been lately found, that an Increase in the Bulk of Water will be occasioned by a certain Degree of Cold, as well as generally by Heat, which render it still more unfit for this Purpose. But that which most of all forbids the Use of Water in a *Thermometer* is, that it will not retain its Fluidity so long as is necessary, but freezes, congeals, or becomes fixed by a certain Degree of Cold.

Euphros. There are different Sorts of *Oils*, which, I presume, may have all stood a Scrutiny in this Respect; pray, what has been the Success in regard to them?

Cleon. Our *Virtuosi* have succeeded greatly in their *Thermometers*, constructed with *Oil*, particularly Linseed-Oil, which as it requires a much greater Heat to make it boil than Water does, or Spirits, or that which melts Wax, Tin, and Lead; but as it can be applied to no greater Degrees of Heat than those, and moreover, as the *Oil*, by its viscid Quality, is apt to stick to, and foul the Tube in which it is contained, the *Oil Thermometer* is of late but very little in Use, though it has been rendered very famous, as it has been rendered a Standard for Experiments on the Weather, by the great Sir *Isaac Newton*; and they are still of considerable Use, where great Degrees of Heat are not required.

Euphros. But is not that Fluid, which we usually call a *Spirit*, a proper Subject for these Purposes? Do not Spirits of Wine, for Instance, expand and contract with Heat and Cold, and thereby answer the *Virtuoso's* Purpose, in a very neat and elegant Manner?

Cleon. It will do so, and accordingly has been, and still is used for that Purpose; but some Objections lie against the Use of *Spirit*; as first, it being colourless it is necessary to tinge it with *Cochineal*, or some such Matter, which, by Degrees, adhering to the Sides of the Tube, greatly sullies it, and obstructs the free Motion of the Spirit. Again, it can shew no greater Degree of

Heat than that which will make it boil, in which Respect it falls very short of the Use of Oil. In the 3d Place, not only Water, and Oil, but even Spirit too, will freeze with an intense Degree of Cold; beside some other Imperfections in a Spirit-Thermometer that might be mentioned.

Euphras. Why then if neither Water, Oil, or Spirit, will answer the Philosopher's Purpose, I suppose we shall be obliged to have recourse at last to Quick-silver; for I can think of nothing else; and I observe, it is what you have in the Thermometer of your Triple Weather-glass; which, as it is designed for your own Use, I presume, you think the best of all others.

Cleon. It generally is the best for all the Purposes of measuring Heat and Cold, the Quick-silver being very dilatable with Heat, and the Attraction between the Particles of Quick-silver being much greater than those of Glass, is the Reason why it will move extremely free with Heat and Cold; to which we may add the Purity, and highest Degree of Fluidity in this Substance above any other; though even a mercurial Thermometer simply, and alone, will not answer every End proposed by those who are very curious.

Euphras. Pray, *Cleonicus*, in what Respect is it deficient?

Cleon. In one material Point, viz. though it really shews the greatest Degree of Heat and Cold that happens; yet, as the Spectator's Eye is not always upon the Tube, he may not be apprised what those greatest Degrees of Heat and Cold were; therefore, may remain ignorant of a Thing he may greatly wish to know.

Euphras. And have you no Remedy, no Invention, for this Purpose at Hand? I think it is Pity if there be not; because it is a Point of such Curiosity, as even I myself, though a Woman, should be glad to be satisfied in.

Cleon. The World, till very lately, has had no Opportunity of observing those nice Particulars. It was somewhat surprising, that so many learned, and curious Gentlemen, who lived in the last Age, should not think of, and communicate a Method for this Purpose. I do not remember in my Reading, it was ever so much as mentioned in their Writings; but, at Length, we are happily possessed with an Invention, that fully answers these Purposes. The attentive Philosopher can now readily ob-

serve

serve the Measure of the greatest Degree of Heat and Cold, as well as of any other. This we receive too from the Hands of a Nobleman, of which curious Contrivance I shall give you a more particular Account by-and-by, when I have more fully informed you of the Uses to be made of the more common *Thermometers*.

Euphros. Well! I shall detain you some Time on this Subject, as I have many Questions to ask of the Uses of that pretty, little Instrument; and, in the first Place, why are the Bores of those Tubes made so extremely small? For unless my Eyes were good, I should scarce perceive the Vein of Quick-silver in them.

Cleon. You will readily conceive the Reason of this even before I mention it, if you did but advert, that the same Quantity of a Fluid will pass through a greater Length in a small Tube than in a large One; by which Means, the Divisions, which measure this Space in the Scale, become larger, and consequently more easily observed; for unless the Quantity of Quick-silver, and therefore the Bulb of the Tube be large, this Space, thro' which it moved in the Bore of the Tube, would not be considerable, unless that Bore was very small.

Euphros. I am afraid you will think me impertinent, if I should ask you how they get the Quick-silver thro' such a small Bore into the Bulb of the Tube.

Cleon. Not at all so; for I like to hear People inquisitive about the Manner of doing Things: that when I observe a Person viewing any Thing, in its own Nature very curious, and, at the same Time, seem not concerned to know how it be done, I always take it for granted there is Want of Genius. — Not that I can pretend to inform you of the whole Process; in this Case it will be sufficient to mention two Particulars; the first is, that they drive the Air out of the Tube with the Flame of a Lamp, and when the Air is gone, any thing Fluid will easily run into it, and therefore the Mercury, from a Paper-funnel placed over the Top of the Tube. 2dly, In order that the Mercury may be as pure as possible, it is first made to boil, and then poured in, not only very pure, but likewise free from Air, and so it will always remain, and by that Means become fit for Use.

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Euphros. You will now indulge me with an Account of the particular Uses of the *Thermometer*; for though I know somewhat of them, yet I would be glad to be still more perfectly informed.

Cleon. I need not tell you, in general, that the Design of a *Thermometer* is to measure the different Degrees of Heat and Cold in the Air, or to shew its various Temperature in those Respects; this always proves a Pleasure, as well as a Curiosity to inquisitive Minds, especially as we can exactly see it measured by the Divisions of the Scale, much better than we can be acquainted with it from any of our common Senses.

Euphros. But I observed, from what I heard a young Physician say not long since, that they must be of considerable Use in Medicine; for he was observing to the Company, that they were the best Index of the Heat of the human Body, and that in a feverish State he could form his Prognostics more certainly by that Instrument, than any other Way.

Cleon. No doubt of it; as the *Thermometer*, placed in the Hand, in the Mouth, or under the Arm-pit, and there held for the Space of a Minute, will undoubtedly discover the Degree of Heat in such a Body; by which it will be easy to understand if it has a Tendency to be feverish, and how far it is so; for which Purpose the several Degrees of Heat are marked upon the *Thermometer*, as you here see; and it would be worth the Physicians while to observe every Degree of Heat, from the least to the highest, in a Fever, and to have a Scale, properly divided by such Experiments, for the Use of the Faculty, and of Mankind in general: We have them in a common Way already, but not with that Accuracy as could be wished. In *Fahrenheit's Thermometer*, which you see here, the freezing Point is marked at 32, a Temperate-heat at 55, the Summer-heat at 75, the Heat of the Blood at 95, and a Fever-heat at 110; but then these Things are all in a vague, and general Way; and, indeed, it would be a very difficult Matter to ascertain them in so accurate a Manner as could be wished.

Euphros. As there are all Degrees of Comparison, and relative to one particular Standard-state of Heat, should not that be first of all fixed upon and determined?

Cleon.

Cleon. Undoubtedly; it ought to be so, if one knew which Way to do it; for this intermediate, or Standard division, which ought to shew what we call the Temperate-state, or Boundary between Heat and Cold, is, in itself, an uncertain Thing.

And if we consider it as a Mean between two Extremes of Heat and Cold, then those Extremes ought, in the first Place, to be determined and fixed before the Mean or Temperate-point can be determined. — If we make the two Extremes, 30 for Freezing, and 80 for the greatest Summer's-heat, in general, then the Difference being 50, Half that, viz. 25, added to the lesser Extreme 30, gives 55 for the Mean, or Temperate-point, as you see it in *Farenheit's Thermometer*; but if one Extreme be a Fever-heat, or Boiling-water, and the other the greatest Degree of Cold, they will give a different Point in the Scale for a Mean between; from whence it is manifest, that no certain Rule can be given, for the Determination of the Mean, or Temperate-point, from any Thing hitherto discovered by Experiment.

Euphros. Then we will suppose it to remain where it is at 35 Degrees. — I further observe, the utmost Extent of your Scale is at Boiling-water, marked 212. Is it not necessary, sometimes, to experiment Degrees of Heat beyond that?

Cleon. Yes, very often; but then we are provided with *Thermometers* of a larger Bore; for the Heat of melted Lead, and Tin, is much greater than that of Boiling-water; and the Heat of a Coal-fire, twice as great as that; and the Heat of Wood-fire, greatest of all; which, therefore, would occasion the Motion of the Quick-silver through a very large Space, were not the Bore of the Tube made proportionably large.

Euphros. But how could you possibly try such Degrees of Heat with a Glass *Thermometer*? You cannot put that into melted Metal or Fire, surely.

Cleon. We certainly can, and do very often, tho' it may seem a Wonder; for Glass will endure any Degree of Heat, without breaking, if there be no Air confined within, and the Quick-silver shews any Degree of Heat, till it boils; which even a Wood-fire will not immediately occasion. To convince you of this, I will shew you one Experiment. — You see here a Spirit-lamp, burning with a clear Flame. — I take the

the *Thermometer* off from the Plate, and hold the Bulb about an Inch above the Flame. — You instantly see the Quick-silver rising up very fast. — I bring it nearer the Flame, and you see it up half Way the Tube. — I now place the Bulb in the Body of the Flame, and the Heat of the Fire causes it to rise to the Top of the Tube. — Were it continued there but a little Time, the Quick-silver would boil, and fly out of the Tube.

Euphros. This is a most curious Experiment, indeed, and a fine, large Instrument, I see, you have provided for this Purpose; by which you can experiment all Degrees of Heat, to that of Fire itself, and it is wonderful indeed. To what other Uses are *Thermometers* applied?

Cleon. To one of great Importance to Botanists, and those Gentlemen who are curious in the Culture of Exotic Plants; and thence it is, we see those Instruments so common in Stoves, Green-houses, and Botanical-gardens, to regulate, and determine the Degrees of Heat necessary for each respective Species of Plants; for as those of Foreign Extraction are brought from different Countries, the Degrees of native Heat, or that peculiar to their Climes, must be imitated, as near as possible, in the Hot-house, and Hot-beds, which alone can be done by a Botanical *Thermometer*; in which you will observe, those Foreign Plants require those several Degrees of Heat against which they are placed; for I have provided one on Purpose here to shew you.

Euphros. This is an elegant Instrument as well as useful; I suppose it is moreover applicable to the Purposes of the Kitchen-garden, in the Hot-beds on which we plant Cucumbers, Melons, &c. in regulating the Degrees of Heat under those large Glasses, which are placed over many different Kinds of Plants, by Gardeners, to forward their Vegetation and Maturity.

Cleon. These are the Purposes to which they are commonly applied, to force, rather than to forward Nature; if it were not the Fashion to have preternatural Diet, we should not observe their Use so frequent in our Kitchen-gardens; but when our Quality make it necessary for us to transgress the Rules of natural Beauty and Order, we have the Honour of eating the choicest Products of the Garden premature, and without their natu-

ral,

ral, agreeable, and wholesome Relish, which People of lower Life must only expect or pretend to.

Euphros. Well! Thanks to my Stars, I am not so high bred; I am willing to wait the proper Times and Seasons appointed by Nature for these Things. The *Asparagus*, *Cucumbers*, *Pease*, &c. in their natural Perfection, and truest Relish, amply reward my Patience, in pleasing my Palate to the highest Degree. It was not long since I was in a Gentleman's Garden, and tried an Experiment of this Kind. A flourishing Vine was growing at the Side of a Hot-house, and one Branch thereof was taken into the said House, and fostered with its unnatural Degree of Heat; the Consequence was, that large Clusters of Grapes were seen hanging on that Branch, when on all the Vine without, exposed to the Coldness of its native Clime, the Blossoms had but just disappeared: I was bid to taste, by the Gentleman, of his Grapes, that I might see how far it was in the Power of Art to assist Nature in her Productions. I did so; but found them far short of that charming Flavour, which those Grapes have, presented by Nature's own Hand, and in her own Time. But to put an End to this Digression; pray, what other Uses are made of these Instruments?

Cleon. They are of excellent Use in philosophical Chemistry; in discovering the several Degrees of Heat which arise upon the Mixtures of different Kinds of Fluids, and Fermentations, consequent thereupon; they will discover great Degrees of Heat, where otherwise none at all would be suspected. Thus, for Instance, a little Oil of Vitrol, poured into a Tumbler of Water, shews, by the *Thermometer* placed in it, a considerable Degree of Heat occasioned thereby, when no Commotion of the compound Fluid appears to the naked Eye. The *Thermometer* is likewise of great Use in Sand-heats, frequently made Use of for Digestions, Solutions, Concoctions, &c. for regulating the requisite Degrees of Heat therein; they might, likewise, be applied to *Papin's Digester*, which cannot be looked upon as perfect without it; but, with it, may be made to answer many more curious, and important Purposes than hitherto it has done.

Euphros. I see in one Frame you have two *Thermometers*, which you call the Standard-*Thermometers* of Newton and Faren-

heit;

best; pray, how do they differ from each other, and why have you of both Sorts? For I observe one is filled with Oil, and the other with Mercury, and their Divisions are different one from the other.*

Cleon. I will explain to you the Nature of the first, viz. Sir *Isaac Newton's*, which is the original Standard of all others, and then you will the better see the Difference between that and the other. Sir *Isaac*, in this, as in all other Cases, had a singular Method of compleating his Design; he contrived to fill his Tube with Oil in such a Manner as to be certain of its Bulk to 1000 Part of the Whole, and the Divisions, or Numbers which you see on the Left-hand Side, express the Expansion, or increased Bulk of the Oil in those Thousandths Parts; thus for Instance, he divides that Bulk of Oil, which it has when Water begins to freeze, into just 1000 equal Parts, as you see marked against that Number in the Scale; after this, any Degree of Heat expands it still more which are measured and expressed by the other Numbers of the Scale above, till at last you come to the Degree of Boiling-water, which expands the Bulk of the Oil to 1074 of those Parts; all which, I presume, you apprehend very easily, from a bare View of the Instrument.

Euphros. I do, very well; but, what are those Numbers I observe on the Right-hand Side of the Tube; having a Cypher, or 0 placed at the Boiling-water, and increasing upwards, and downwards, by the Intervals of 6 Divisions?

Cleon. By these, Sir *Isaac* expressed the comparative Degrees, or rather Differences of Heat, for any given Quantities of its Bulk. Thus 6 Degrees of Heat above that of Boiling-water, expand the Oil 13 Parts of 1000, or raise it to the Number of 1013, and so on all the Way up the Scale; likewise, the same Difference of 6 Degrees below the Point of freezing contracts the Bulk of the Oil, or makes it stand only at 987 in the Scale.

Euphros. This I likewise clearly apprehend. But how comes *Farenheit's Thermometer* to be reckoned a second Standard?

Cleon. After mercurial *Thermometers* were found to be best, it was thought proper to have one of this Kind made from the *Newtonian* Standard, and that of *Farenheit's* being most in common Use, it was pitched upon for this Purpose, as it were, by the

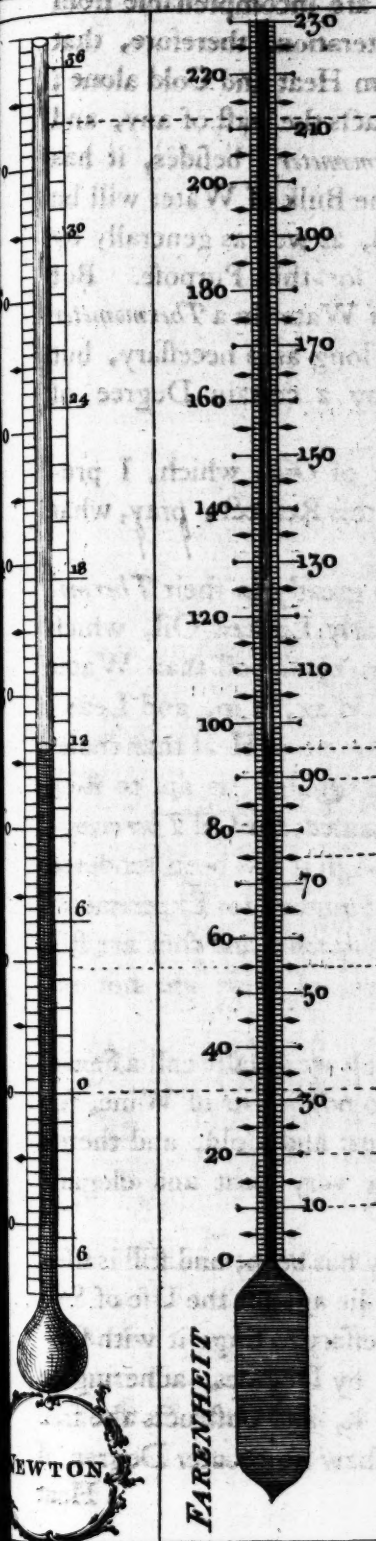
* See Plate XXVII.



The Standard THERMOMETERS

NEWTON & FARENHEIT.

Plate XXVII.



Water Boils

Spirit of Wine boils

Wax begins to melt

Greatest Fever Heat

Fever Heat

Blood Heat

Greatest Summer Heat

Summer Heat

Temperate

Water begins to Freeze & Snow to Thaw

Hard Frost

Very hard Frost

the Air, Water, or Earth, in which they grow, and the Temperature is found to be the principal Instrument for all the

As this is the case, it will undoubtedly follow that the language of John of a philosophic Turn, must be used and introduced in different forms and structures.

and officers at the time of the trial, the Nation

in general, and to you some

the first place, therefore, you would observe that even the best estimates or methods of the Bureau which it is

of Boston will be a proper illustration of the

1. The first step is to identify the problem or question that needs to be answered. This involves understanding the context and the specific requirements of the task.

1. The first of these is the fact that the majority of the population of the United States is now living in urban areas. This is a result of the process of urbanization, which has been going on since the beginning of the 20th century. The population of the United States has increased from about 100 million in 1900 to over 200 million in 1950, and the majority of this increase has been in urban areas. This has led to a concentration of population in a few large cities, which has in turn led to a number of problems, such as overcrowding, pollution, and traffic congestion.

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the general Consent of the Public, tho' the Divisions upon it are entirely arbitrary, and not the best, by much, that might have been chose for this Purpose; but it is in vain to oppose any Thing that is established by a general Use, or Custom, tho' in itself ever so inartificial, or absurd.

Euphros. Then Philosophy itself is subject to the same Inconveniencies, as many other Sciences, and Professions; and if Philosophy cannot mend the World, and reduce Mankind to Reason, I know not what will; according to the Proverb *There is no general Rule without an Exception.* I suppose every Body will not blindly follow *Farenheit* in the Division of their *Thermometer* Scale.

Cleon. They do not; for several Societies and great Philosophers have chose other Methods; of which the late Dr. *George Martin* has given an Account of a great Number, in his Treatise on this Subject; but still, those who are curious, and would communicate their Observations to the Public, are necessitated to have Recourse to the above-mentioned Scale. And thus much may suffice, for the present, for the Nature and Use of Simple *Thermometers*.

Euphros. By this you imply, there are Compound *Thermometers*, as well as *Barometers*.

Cleon. There are such, and made of the same Materials too, nearly, *viz.* Quick-silver and Spirit put together in an inverted Tube; by which Means the Scale of Motion in the Quick-silver is enlarged, and therefore, the Bore of the Tube is not required to be so very small; hence, Observations are more easily made by the Compound than by the Simple *Thermometer*.

Euphros. This, one would think, must be a considerable Improvement of this Instrument; I shall be obliged to you, if you would explain the Reason of its Operation more plainly than I yet apprehend it.

Cleon. This I shall do, by presenting you with a View of the Instrument in two different Forms. In the first, the Tube is bent but once, and in the other, twice; as you see by the Specimens I here present you. You observe, one Part of the Tube is large, and filled with Spirits, and the smaller and longer Part contains Quick-silver. The larger Part, which holds the Spirit, is sometimes of a globular, and sometimes of a

cylindric Form; which latter is most convenient, because in that, the Heat can more immediately affect, and dilate the Spirit; and because the Spirit, with the same Degree of Heat, will be expanded much more readily than Mercury, and may be more conveniently contained in a much larger Quantity, it will, as I said before, by its Expansion, cause a greater Motion of the Quick-silver; and therefore, admit of a larger and more convenient Scale. The same Thing may be said for the other, in the second Form; but the noble Author of this Invention had another Point in view, which was, to shew the Measure of the greatest Heat and Cold that should happen in the Course of the Year, by the peculiar Construction and Mechanism of these Instruments.

Euphros. I believe what you now mean relates to the Bulb, which I see on the Top of the Tube of the first Form, in which I observe a small Quantity of a Fluid, and a very fine Piece of Glass standing up in the Middle of it, and inclining, towards the Top, to one Side of the Bulb; but what the Use and Intent of all this is, I am not able to conceive.

Clem. In this very Part, as you rightly observe, consists the critical Use of this Instrument. That fine Piece of Glass, as you call it, is only a very fine, capillary Tube, which the Upper-end of the long Tube is drawn into by the Art of the Glass-man; over this fine Part, he has dextrously fixed that hollow, glass Bulb, with which the Tube, by Means of the fine, capillary Part, communicates; for that, you must know, small as it is, is hollow throughout.

Euphros. Well; that is more than I should have mistrusted; I can see no Hollowness in it; but supposing that, what is the Use of the Fluid, that I see in the Bulb, and in the Tube below it?

Clem. You will understand, my *Euphrosyne*, that after the proper Quantity of Spirit and Quick-silver is put into the Body of the Tube, then the remaining Space above the Quick-silver is filled with a small Quantity of the same Spirit; then the Tube being drawn out, on the Top, to a capillary Form, and the Bulb fixed over it, it must follow, that when the Quick-silver rises in the Tube, by the Expansion of the large Body of Spirit, then that Spirit above the Quick-silver in the Tube will necessarily be driven thro' the fine, capillary Part,

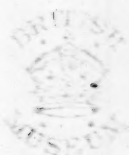
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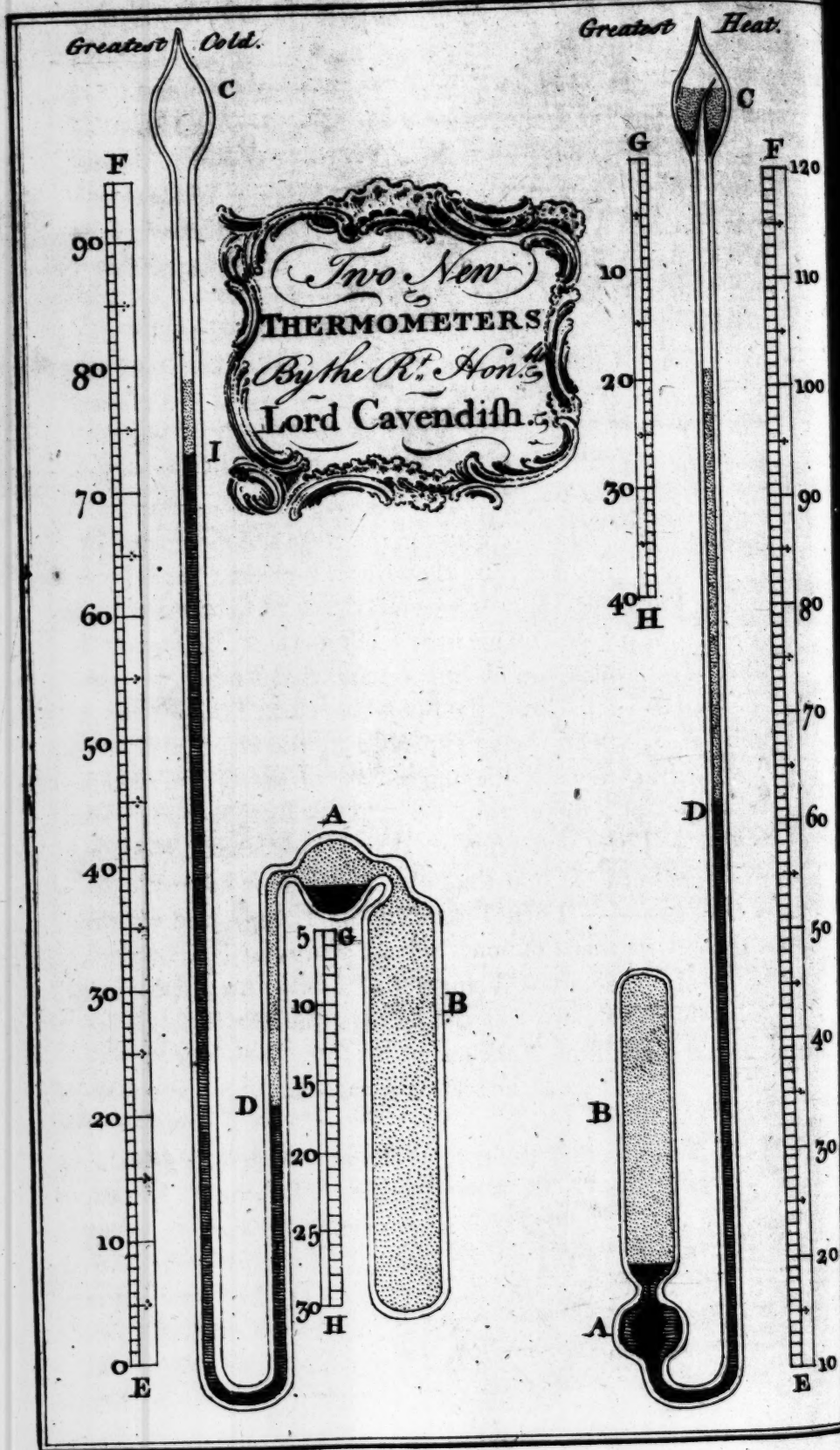
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Part, into the Bulb, and falling to the Bottom cannot possibly return; therefore, a Vacancy will be left between the Quick-silver and the Spirit above it in the Tube; and this will be greater in Proportion, as the Quick-silver has risen higher in the Tube, and therefore, since the greatest Degree of Heat will cause the greatest Vacancy, between the Quick-silver and Spirit, it will plainly shew the highest Elevation of the Quick-silver that has happened during the Absence of the Observer.

Euphros. Can you explain this to me by an Example?

Cleon. Yes; I have provided two *Thermometers* for that Purpose; the first of which, you see, in this Frame, with two Scales, E F G H, one large, and the other small; the first measures the Rise of the Quick-silver at D, by the Expansion of the Spirits, in the Part B: The Second, G H, measures the Vacancy in the Tube above between the Bulb and the Spirit, by which, at any Time, it may be known how high the Quick-silver has risen in the Tube, since it was rectified for Observation.

Euphros. What do you mean by rectifying this *Thermometer*?

Cleon. I will shew you by Experiment what I mean.

You see here a Spirit-lamp, the Flame of which I bring near to the Spirit at B, which, being expanded by the Heat, will raise the Quick-silver towards the upper Part of the Tube, which will drive the Spirit there, thro' the capillary Part, into the Bulb at C. Then you observe, that I hold the Instrument very much inclined, so that the Spirit may always cover the capillary End. Then I remove the Lamp, and let the Tube remain in that Position, till the Spirit, at B, cools, or gets to be of the common Temperature of the Air; then will the Quick-silver subside, and the Spirit, from the Bulb C, fill all the upper Part of the Tube above.

Euphros. This I see is the Case; and what am I to learn from hence?

Cleon. You observe, the present Temperature of the Air is such, as makes the Quick-silver stand at 60 Degrees; suppose you observe it no more till To-morrow at this Time, and then you see the Spirit at the Top stand 19 Divisions below the Bulb in the Scale, G H; that will shew, that so many Divisions is to be added to the Height of the Quick-silver where you then see it, and that will give the greatest Height (*viz.* 89th Division) to

which it has risen in the mean Time; and thus you may proceed, by refitting the Instrument for any other Time. One Thing you may observe, and that is, that the Spirit above the Quick-silver will be expanded by Heat, and therefore, occasion a small Degree of Irregularity in this Instrument. But as it amounts to no more than about a 6th Part in a Rise of Ten, it will not be worth regarding in common Use.

Euphros. I understand the Design of this Instrument perfectly well. But, what is this other crooked Instrument in the Frame, which seems of a more complicated Structure than the Former.

Gleason. There is not much Difference, if you will observe; it consists only in this, that the Ball A, in the Former, was in a vertical Position, and the Cylinder, B, pointed upwards; whereas, in the Latter, the Ball, A, is in a horizontal Position, and the Part B is turned downwards.

Euphros. The Rationale of this Contrivance, I presume, I shall understand when you have explained it.

Gleason. You will, very easily; having first observed, that there is a Communication between the Cylinder, B, the Ball, A, and the Syphon of the *Thermometer*; so that, when the *Thermometer* is filled with Quick-silver, and Part of the Ball, A, the Spirit from B fills the other Part, and in this Case, it will be fixed in an upright Position for Observation; then it will follow, that, if the Weather becomes colder, the Spirit, in B, will be contracted, and more of the Quick-silver will distil from the *Thermometer* into the Ball, A; after which, when the Weather becomes warmer, the Spirit, in B, will expand, and cause the Quick-silver, of Course, to retreat from the Ball, A, in the shorter Leg, to D; the Distance of which is measured in the short Scale, GH, which Number of Divisions there is to be subtracted from that Number at which the Mercury stands, at I, in the longer Leg. Thus, for Instance, suppose that the Quick-silver, at D, be 17 Degrees below the Center of the Ball, A, and that the Mercury, in the longer Leg, at I, stands against 75, then from 75 you deduct 17, and there will remain 58, to which the Quick-silver has subsided with the greatest Degree of Cold that has happened since the Instrument was fitted for Use: And thus, by filling the shorter Leg with Quick-silver, from the Ball A,

which

which is done by reclining the Instrument 'till the Mercury in the Ball, A, lies over the Orifice of the Tube, then the Spirit, in B, being a little heated, will drive it into the Tube by Degrees, 'till it is filled to the Top, and united with that in the Ball; in this Position it must remain 'till the Spirits become cold, and then it is fitted again for Observation; and if, in the Beginning of the Winter, it be in this Manner prepared, it will shew the greatest Degree of Cold that has happened during the whole Winter, by the greatest Length of Spirit in the shorter Leg, measured in the Scale G H. There are several other minute Particulars relating to this Instrument; which, if you chuse to be farther satisfied about, you may, at your Leisure, consult the 38th Number of the *Philosophical Transactions*, Vol. I. Part I. for the Year 1757.

DIALOGUE X.

Of the Nature and Use of HYGROMETERS.

Euphrosyne.

BESIDES the *Barometer* and *Thermometer*, you mentioned another Instrument used in philosophical Enquiries, which you called an *Hygrometer*; pray, is it of Moment enough to require any of your Time in the Description thereof?

Cleon. It is not to be expected, that every Thing should be of equal Use and Concernment; and since these Instruments are designed to shew the Moisture and Dryness of the Air, they cannot be supposed unworthy the Observations either of a Philosopher, or a prudent Man; for we find, by Experience, that most Things are affected by the Moisture and Dryness of the Air, and particularly the Animal Œconomy, the Causes of the minutest Variations in which it is of the utmost Consequence to explore; as a dry Air, whether hot or cold, is always healthy, so a moist, or damp Air, is well known to be productive of many Disorders to Mankind, as Colds, Rheumatisms, Pains in the Joints, and many other dangerous Diseases; an Index, therefore, to shew constantly, the different State of the Air, in a Room where we usually sit, must be considered as one Thing necessary towards

wards the Preservation of our Health; and we cannot be too well prepared against the Attacks of so great a Number of Disorders that we are liable to from every Quarter.

Euphros. What are the Forms of those Kinds of Instruments, and which would you recommend as the best?

Cleon. Many are the Contrivances, and the different Forms of those Instruments, which the Ingenuity of Men have contrived, and also, the Materials of which they have been made, which depend, in general, upon three different Principles, viz. first, the Expansion, or Contraction of Bodies, by Moisture and Dryness; secondly, the Increase, or Decrease of Weight, from the same Causes; thirdly, the different Motions of the same Body occasioned by those different Qualities of the Air.

Euphros. Will you be so good, as to illustrate these Things, *Cleonicus*, by Examples?

Cleon. Every Plank, or Board becomes an *Hygrometer*, by expanding or contracting with Moisture and Dryness; which you see very often in the Pannels of the Wainscot, the Doors of the Room, &c. are found narrower and wider, as the Air is more or less dry; particularly in Fir, the moist Particles of Air insinuating into the Pores of this Wood will cause a considerable Increase of its Dimensions, laterally or Side-ways; and therefore, if several Pieces of a Deal-board were sawn off a-cross the Grain, of about an Inch wide, and then glewed together by their Ends, they would, by this Means, make a very convenient *Hygrometer*; as the Difference would, by this Means, become very different, and easily variable, by Moisture and Dryness; and such a compound, lignous *Hygrometer* might, in many Cases, answer very good Purposes.

Euphros. This is a very natural, and curious Contrivance; and, pray, what Forms arise from your second Principle, the Increase of Weight?

Cleon. You will easily apprehend, that any Body, of a spongy Substance, will naturally attract and imbibe the moist Particles of the Air, and thereby, of Course, become heavier. Hence, then, if a fine Balance, or Stilyard be provided with a large Piece of Sponge, hanging at one End, and equipoized at the other, in a Middle State of the Air; and then if the Slyte, or Cock of the Balance, be made to move over a graduated Circle,

as the Sponge became heavier, or lighter, by Moisture and Dryness, it will be shewn by the Degrees, on one Side or the other of that middle Point; and to keep this Equipoize, in different Weights of the Air, a fine Chain is usually fixed to the Bottom of the Balance, Part of which is supported by a Stand for that Purpose; and as the Scale, or Beam of the Silyard rises higher or lower, so the greater or lesser Quantity of this Chain will constantly preserve the variable Equilibrium. But in making *Hygrometers* of this Kind, the Piece of Sponge should be first prepared by dipping it in a Solution of Salt of Tartar, *Sal Armoniac*, &c. and then dried again; for by this Means, the Sponge becomes impregnated with Salts, which attract more readily a larger Quantity of Moisture in the Air; also those spongy Bodies should be very thin, in order to have as much Surface exposed to the Air as possible, by which Means the Variation will be the more easily discovered.

Euphras. And what Sort of *Hygrometers* are derived from your third Principle?

Cleon. Any Thing that is naturally of a spiral, or twisted Form; particularly the Beard of a wild Oat, and that of some other Vegetables; for the Moisture of the Air insinuating into the Pores, or between the Parts of those Bodies, expands them, lessens their natural Elasticity, and causes them to unbend, or gradually to become untwisted; as on the Contrary, when from a moist State in the Air it becomes dry, those Particles by Degrees are exhaled, and the Beard returns again, by Degrees, to its original, twisted Form; and therefore, if the Beard of a wild Oat be placed in a Perpendicular, and a fine Index placed on the Top of it, over a small Circle, divided into Degrees, it will naturally shew the Moisture, and Dryness of the Air, by its Motion backward or forward over the several Parts or Divisions thereof. And these, I think, are the principal Kinds of *Hygrometers*, which have been hitherto invented. I am not, indeed, provided with one of every Sort, to shew you; but have a Print of them, which will communicate the Ideas of their Construction and Use as perfectly as the Instruments themselves.

Euphras. I apprehend the Nature and Design of them all very well, from the Prints; but you have not yet told me which Form or Construction you think the best of all others.

Cleon.

Cleon. It is difficult to say which is the best, some having an Advantage in one Respect, and some in another; but that which is most convenient for general Use, and yet very exact at the same Time, is what makes the third Part of the triple Weather-glass. This consists of a long, twisted Cord, which you see strained over the Frame of this *Barometer* in a horizontal Position.

Euphros. I do not clearly see how this Cord operates as an *Hygrometer*. I easily apprehend, that it must be alternately slacker or tighter, as the Weather is dry or moist; but, how is that Index, which I see on the upper Part of the Plate, moved backward and forward over the Semi-circle, by that Means?

Cleon. For this Purpose, there is a little Wheel and Axle placed in the back Part of the Frame, which is very freely moveable. About this Wheel, the fine Piece of Silk-string, which you see hang from the Middle of the Cord, is put with a small Weight hanging at the End; so that, when the Cord relaxes or contracts, the Middle Part will descend and ascend, thro' a small Space; and consequently, by the String, the Wheel will be moved a little one Way and the other. The End of the Axle of this Wheel comes to the Out-side of the Plate, thro' the Center of the Semi-circle; on this the Index is screwed, and, as the Wheel and its Axle move by the String from the Cord, the Index, of Course, must be carried from one Part of the Semi-circle to the other.

Euphros. You have convinced me to my Satisfaction. I easily see, that when the Cord relaxes, by the Driness of the Air, it must descend a little in the Middle Part, the Silk-string there, by its Weight, will carry the Wheel a small Matter round, and move the Index over the Right-hand Quarter of the Semi-circle, shewing the several Degrees of Driness in the Air; but when the Air is moist, the String will swell, contract, and rise again in the Middle-part, and carry the Index back to the other Part of the Semi-circle on the Left-hand, and there point out the particular Degree of Moisture.

Cleon. Your Ideas are very just; and I have only one Thing more to observe, in regard to this *Hygrometer*, that as it is the most simple in its Structure, so it is the most accurate for Use, and the least expensive in the Form.

Euphros.

Euphros. I observe your main Drift in every Thing is the greatest Accuracy, joined with the least Expence, in the Structure of Machines for philosophical Purposes; and if one of this Sort will do so very well, it must certainly render this Weather-glass (for indicating at once all the different and important Qualities of the Air) a very useful Contrivance. Having detained you, I think, long enough on this Sort of Instrument, I shall be glad of an Opportunity, when you are next at Leisure, to have your Instructions concerning the Nature and Use of that very celebrated Machine, the AIR-PUMP, which I have heard so much Talk of, but have never yet seen any Experiment made with it.

Cleon. Our next Conversation, my *Euphrosyne*, will be on that Subject; and nothing which the Field of Philosophy affords can more highly gratify your Curiosity, or improve your Understanding, than Experiments made therewith. As we have now surveyed the Nature and principal Properties of the vast surrounding Atmosphere, and also of many different Species of Meteors generated therein, I think, it will be proper for you to conclude this Speculation at present, by reading the poetical Description of this Subject, by the Author of the Poem, called, *Universal Beauty*, which I shall leave with you for that Purpose.

*While Ocean thus the latent Store bequeaths,
Above, its humid Exhalation breaths;
Its Bosom pants beneath the vigorous Heat,
And eager Beams th' expanding Surface beat;
Insinuating, form the lucid Cell,
To Bladders the circumfluous Moisture swell;
Th' inflated Vapours spurn the nether Tide,
And mounted on the weightier Æther ride;
As tho' in Scorn of gravitating Pow'r,
Sublime, the cloudy Congregations tour;
O'er torrid Climes, collect their sable Train,
And form Umbrellas for the panting Swain;
Or figur'd wanton in romantic Mould,
Careering Knights, and airy Ramparts hold;
(Imblaz'ning Beams the fitting Champions gild,
And various, paint the visionary Field;)*

Sudden the loose, enchanted Squadrons fly,
 And sweep Delusion from the wond'ring Eye;
 Thence, on the floating Atmosphere they sail,
 And steer precarious with the varying Gale;
 Or hov'ring, with suspended Wing delay,
 And in Disdain the kindred Flood survey.
 When lo! th' afflicting Ether checks their Pride,
 Compressing ebb, the vain dilated Tide;
 Their sp'ring Essence to its Center sprinks,
 And a cold Nuptial their Coherence links,
 With artful Touch, the curious Meteor forms;
 Parent, prolific of salubrious Storms,
 (When from on high the rapid Tempest's hurl'd,
 Enliv'ning as a Sneeze to Man's inferior World.)
 The frigid Chymist culls the min'ral Store,
 The glossy Sphærules of metallic Ore;
 Sublimes with Nitre and sulphureous Foam,
 And hoards Contagion in Heav'n's ample Dome;
 Where Nature's Magazine fermenting lies,
 Till the bright Ray athwart the Welkin flies,
 High Rage the small Incendiary inspires,
 Whose kindling Touch the dread Artillery fires;
 Quick, with Effusion wide, the Lightnings glare;
 Disploding Bolts, the cloudy Entrails tear;
 The cleansing Flames sweep thro' th' etherial Room,
 And swift, the gross infectious Steam consume,
 Our vital Element the Blaze refines,
 While Man, ingrateful, at his Health rapines.
 With various Skill, the chilling Artist works,
 And Operator chief, in ev'ry Meteor lurks;
 Oft, where the Zenith's lofty Realms extend,
 E'er Mists, conglobing, by their Weight descend,
 With sudden Nitre captivates the Cloud,
 And o'er the Vapour throws a whitening Shroud:
 Soft, from the Concave, hov'ring Fleeces fall,
 Whose flaky Texture cloaths our silver Ball.
 Or when the Show'r forsakes the sable Skies;
 Hap'ly, the Cold in secret Ambush lies,

Couching.

Couching, awaits in some inferior Space,
 And chills the Tempest with a quick embrace;
 The chrysal Pellets at the Touch congeal,
 And from the Ground rebounds the murmur'ing Hail.
 Or constant, where this Artificer dwells,
 And algid, from his Heights the Mist repels;
 Th' ALMIGHTY ALCHEMIST his Limbeck rears,
 His Lordly Taurus, or his Alpine Peers;
 Suspending Fogs around the Summit spread,
 And gloomy Columns crown each haughty Head,
 Obstructed, drench the conspicing Hall,
 And soaking, thro' the porous Grit distil;
 Collecting from a thousand thousand Cells
 The subterraneous Flood impatient swells;
 Whence issuing Torrents burst the Mountain's Side,
 And hence impetuous pour their headlong Tide.

DIALOGUE XI.

Of the INVENTION and CONSTRUCTION of the
 AIR-PUMP.

Euphrosyne.

THE present Hour, I see, is destined for my Information in
 a Part of Knowledge that I have as yet few or no Ideas of.

— This Machine, I presume, is what you call the *Air-
 Pump*; it appears to be of a curious Form and Make; and I
 shall be highly pleas'd with a short Account of the original, or
 first Invention of it. Can you tell any thing of that Matter,
Cleonicus?

Cleon. The Inventor of this famous Machine was *Otto Gu-
 ricke*, a Consul of *Magdeburg*, who, some time before the Year
 1654, first contrived and brought it into Use; for it was then,
 that this ingenious Gentleman, being employed in a public Ne-
 gotiation at *Ratisbon*, had an Occasion offered him of shewing
 his Instrument to the Emperor, and some other Princes there
 present; among whom, the Elector, and Archbishop of *Mentz*
 were particularly delighted with the Contrivance of the Instru-

ment, and the curious Experiments exhibited by it; insomuch that he became very desirous of having such another Machine made for his own Use: But this could not easily be effected, by Reason of the short Stay they had to make at *Ratisbon*, and for want of skilful Workmen. However, he prevailed with the Inventor to part with his own Apparatus; and at his Return, carried it home with him to *Wurtzburg*. Here it was, that the learned and diligent Jesuit, Father *Schottus*, being then Professor of the Mathematics in that University, had the first Sight of it, together with some other curious and learned Persons. The Archbishop was pleased to give them an Account of the Engine; and a Relation of the Experiments he had seen the Inventor perform at *Ratisbon*. These they tried over several Times in his Presence; and it was not long before they themselves also made several other new ones of the like Nature.

Euphros. I do not wonder at their being highly delighted with such a curious Invention, and which, I suppose, soon made a great Noise in the World at that Time, and soon reached the Ears of most of the *Virtuosi* in *Europe*.

Cleon. Indeed it did; principally by Means of the large Correspondence which *Schottus* held with learned Men in most Parts of *Europe*; but more especially by a Book, which he published in the Year 1657, in which, and in an *Appendix* added thereto, he gave a distinct and full Account of this Machine, and the *Magdeburgic* Experiments, as he calls them. After this, in the Year 1664, he published another Book, giving a farther Account of the Experiments that had been made since the printing his Former; and last of all, in the Year 1672, the famous Inventor himself, *Otto Guericke*, was pleased to give a most perfect Narrative of his own Trials, in a Book, which he calls, *New Magdeburgic Experiments in Vacuo*. These Books all explain the original Construction of this Instrument, which, it must be confessed, was very awkward and imperfect, in Comparison of the Forms in which they are now made; for, in order to try Experiments with them, they were obliged to place their Glasses, and other Vessels (from which they would exhaust the Air) under Water, in order to prevent the Air from getting in again.

Euphros.

Euphros. No Wonder, if there has been a gradual and very considerable Improvement in an Engine of such an extraordinary Nature, and I imagine, it was not long before some of our *British* Geniusses took it in Hand; for I have often heard it observed, that the *English* never fail to improve upon the Hints they receive of any foreign Invention; and, indeed, I have heard so much Talk of *Boyle's* Air-pump, that I really took it for granted, he was the Inventor of it. I suppose, therefore, it was he, among our Countrymen, who first made any Progress in its Improvement.

Cleon. So far you are right, Sister; and Multitudes think as you do, that Mr. *Boyle* was the Author of this Invention, from its having been so generally called the *Machina Boyleana*; and the void Space produced by it, the *Vacuum Boyleanum*: But these Appellations were rather the Consequence of his great Improvements in the Fabric of the Machine. His new Method of trying Experiments with it, and the numberless useful Purposes to which he applied them, the Glory of which has, in a Manner, totally obscured all that had been heard of before in the *Magdeburgic* Experiments. Mr. *Boyle* himself gives a true Account of the Invention of this Machine, as I have now mentioned, in a Letter, which he wrote to his Nephew, the Lord *Dungarvon*, at *Paris*. Two Years after *Schottus's* Book was first published, he does, indeed, say, that he had some Thoughts on the same Subject before he had heard of those Gentlemens Performances Abroad; but that they had really anticipated him in the Invention of the Machine: But he observes to his Lordship the great Imperfections the Invention then laboured under, and imployed two Gentlemen, Mr. *Gratorix* and Mr. *Hooke*, afterwards Dr. *Hooke*, to contrive some *Air-Pump*, which need not, like that other, be kept under Water, and be more easily and generally applied to Use, which after some unsuccessful Trials was at Length accomplished.

Euphros. Are the Air-pumps now in Use of this original Form of Mr. *Boyle's*.

Cleon. No; far enough from it: His own Alterations were not a few. Dr. *Hooke's* Pump served him not long; another Form, invented by Mr. *Pappin*, pleased Mr. *Boyle* still better, and successive Changes and Improvements were made; till at last,

last, it arrived to the Perfection which it received from the Hands of that excellent Operator, the late Mr. *Hawksby*, which is still one of the Forms in Use; and is this large Engine, which you see in this upright Frame.

Euphros. An elegant and noble looking Machine, indeed. Pray, what may be the Expence of it?

Cleon. This, which you see in this Mahogany Frame, with this large Apparatus of Glasses, Brass-work, &c. cost 30 Guineas.

Euphros. I do not think it dear. Were I a Man, I should much sooner part with that Sum of Money for such an Object, than hundreds of others, on which it is often expended. In Truth, I wonder at nothing more, than to see how free and ready Gentlemen are in the expensive Purchases of trifling Subjects, and negligent of those of the greatest Curiosity, and most general Importance. — But, I observe, you have other Forms of Air-pumps; three of which, I see, here upon the Table. Pray, what is peculiar to each of them?

Cleon. Two of these are also double barrell'd Air-pumps, and the other is a single One. The first, or largest, was made for the Conveniency of placing it upon the Table, while the Operations are performed on it. These were made, at first, by one *Davenport*, and called, *Davenport's Table Air-pump*. The Second was contrived to be of a portable Form, and to reduce the Mechanism to a still more simple Structure. This, therefore, is called, the *portable Air-pump*. The last is a single barrell'd *Air-pump*, and is a singular Improvement of this Machine for such, as are very curious in *pneumatical* Experiments.

Euphros. The external Appearance of these Machines must highly delight the Eye; but the *Rationale* of their Structure and Usefulness, I presume, depends upon a particular View of their internal Parts.

Cleon. It is certain, you cannot know the Nature, or Use, of an *Air-pump*, without being particularly acquainted with its internal Structure and Parts; and I propose, in the next Place, to analyze one of them, or take it to Pieces; and you will find, that the constituent Parts are not many, and their Uses not difficult to be understood. For this Purpose, I shall take in Hand the portable

portable *Air-pump*, as that contains no more Parts than are absolutely necessary, in a Form where two Barrels are used.

Euphros. The Parts of this Pump are so few in Appearance, that, I imagine the Dissection of it will not be either tedious or troublesome.

Cleon. It will not in the least. — For you see, I only take these Screw-pins out, and the Head, or Top of the Pump, divides itself into two Parts, which fall off; shewing the Wheel, with the Pisterns, on each Side, which it moves alternately up and down in the Barrels, when itself is turned round by the Winch.

Euphros. This I plainly perceive, and that the Use of the Frame is only to keep these Parts together in their proper Positions, in working the Instrument.

Cleon. I remove the Wheel, and the Barrels easily come off, as they were only before pressed down by the Frame of the Pump, which screws on the Top for that Purpose. The Cavity of these Barrels is exactly fitted, by the lower Part of the Pisterns, by Means of Leather, suppled with Oil, screwed on to each; so that no Air can, or ought to pass between them and the Barrels. The next Thing that you observe is, that the Piece, screwed on at the Bottom of each Pistern, is perforated with a Hole through the Middle, over which Hole, you see is tied a small Piece of Leather, which is called the *Valve*; and as this Part is screwed into the Pistern, this *Valve*, opening upwards, gives a Passage for the Air through it from below. — Again, in the Brass Plate, on the Bottom, you see other Pieces of Brass screwed in, having Holes, in like Manner, through them, with the same Leather *Valves* on the Top, as before, in the Pisterns; so that, by this Means, there is a Passage for the Air from any Receiver, placed on the circular Plate of the Pump, to the Cavity of the Barrels below, which stand over those Parts; for this large Plate of the Pump is perforated with a Hole, quite to the Center of the Fore-part, and thence cross-wise on each Side the Barrel. — These Parts, few as they are, are all that are essential to Pump-work of any Kind; for there is no Difference in the Nature of the essential Parts of a Pump, whether it be for exhausting Water, Air, or any other Fluid.

Euphros.

Euphros. These Parts, I observe then, are only two Barrels, two Pisterns, one Valve in each of them, and one Valve under each Barrel, in the Plate of the Pump; besides the Wheel, which gives Motion to the Pisterns: — But how am I to understand the *Rationale* of working this Machine, when all the Parts are put together in their proper Place and Order?

Cleon. You will thus easily understand it, by considering the Thing in a proper Manner; that is, the Action of one Barrel by itself alone. — In the first Place, you see the Pistern is placed at the Bottom of the Barrel; and it is supposed, that it fits the Barrel so very nicely, as to leave little or no Air below it. — Then (secondly) I turn the Winch, and lift up that Pistern to its proper Height. — Thirdly, in doing this, I lift up the Column of Air that stands over the Pistern, and thereby make, in the Cavity below, a Space, in a great Measure void of Air, supposing that none could enter into it thro' the Valve in the Plate of the Pump. — Fourthly, but upon lifting up of the Pistern, the Air from the Receiver, placed on the Pump, will not suffer this void Space in the Barrel; but, by Means of its Spring, will rush into the Barrel thro' the Valve at the Bottom, till the Air in the Barrel, and in the Receiver, be of equal Density; and consequently, That in the Receiver is by this Means rarified, or becomes less dense, by being expanded into a larger Space. — Do you understand me thus far, my *Euphrosyne*?

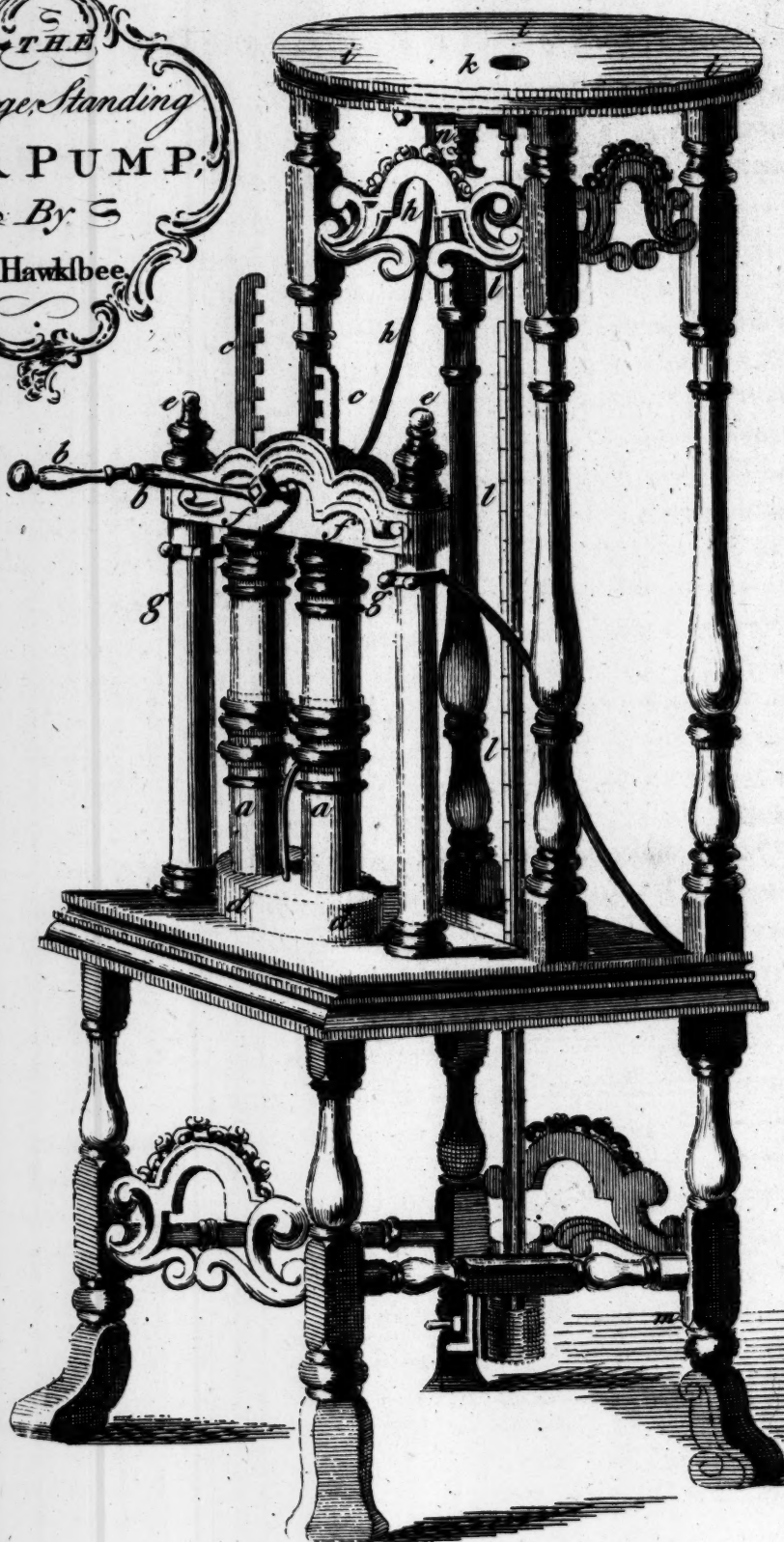
Euphros. I believe I do pretty well; but as yet you have performed but one half of the Operation.

Cleon. 'Tis true, we have not; for the Pistern, in the next Place, must be carried down to the Bottom of the Barrel again; by raising the Pistern up, we have brought some of the Air out of the Receiver into the Barrel, and now by depressing the Pistern, we shall get it out of the Barrel too, and so get rid of it quite. — Thus I force the Pistern down to the Bottom, by turning the Winch the contrary Way; in which Action, you'll observe, (first) That, as the Pistern goes down, the Air, contained below it in the Barrel, as it cannot return thro' the Valve at the Bottom into the Receiver, must be condensed by Degrees, till at length, it becomes of equal Density to the external Air above the Pistern. (Secondly) After this, as the Pistern descends lower, the Air will become more condensed in the Barrel than the

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THE
Large Standing
AIR PUMP,
By S
M. Hawklbee.



the outward Air, if it had no Passage through a Valve in the Piston; but, as there is such a Passage, it can suffer no greater Condensation; because, by its greater Spring, it will rush thro' the Valve in the Piston, and make its Escape into the common Air, from whence it cannot return, as we have before said, by reason of the Valve in the Piston shutting downwards, by the Pressure of the incumbent Air. Thus we have exhausted a Part of the Air out of the Receiver, and the remaining Air will be gradually very nearly all exhausted, in the same Manner, by the constant Working of the Pump; for the Piston in the other Barrel does the same Thing, as you have now seen; and as they are both worked by the same Stroke of the Winch, their Action may be alternately repeated, till the Air is exhausted from the Receiver, as far as is required.

Euphras. My dear *Cleonicus*, you take great Pains to inform me; and, I hope, I am not so dull a Scholar, but that I can in general understand all that you have said; and I doubt not, when I come to see several Experiments of this Nature performed, I shall gradually get a more perfect Knowledge thereof.

Cleon. I make no Doubt but you will; for bare Instruction, without an Illustration by Experiments, will require, not only great Capacity, but great Attention, to comprehend what will otherwise be very easily deduced from Facts, joined with a proper Method of reasoning on them.

Euphras. I presume the Mechanism of the Pump, in the several Parts we have now described, is the same nearly in all the different Forms.

Cleon. It is so, in those which you see consisting of two Barrels; and likewise, in the single Barrel Pumps of the common Sort; but that One which you here see is of a peculiar Make, the Rationale of which deserves, in a few Words, to be explained; in order to which, it must be observed, that, when the Piston is raised in a single Barrel, as the Weight of the Atmosphere lies upon it, so that Weight lies upon the Hand, in every Stroke of the Piston. Indeed, when we first begin to work the Pump, that Weight is insensible, by reason that the Spring of the Air below the Piston is equal to the said Weight above it; but in every Stroke of the Piston, the Spring

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of the Air below it, which comes from the Recipient, is diminished, while the Weight of the Atmosphere in the Piston remains the same; and therefore, will be more and more sensible, as you proceed in working the Pump; till at last, when the Air is nearly all exhausted from the Receiver, the whole Weight nearly of a Column of Air, upon the Surface of the Piston, must be raised by the Hand alone, without any Assistance from the Spring of the internal Air.

Euphros. I apprehend what you say, and must naturally ask this Question; why then are such Pumps in Use? For the Labour must needs be very great in working them, as you have heretofore convinced me, that the Weight of the Air, upon a circular Inch, is 12 Pounds, and consequently, if the Piston of the Pump be any thing considerable, such a constant Weight of the Air, and the Labour it causes, would discourage the Use of such Pumps.

Cleon. The Query you put is very pertinent; to which it is replied, that if the Piston be made smaller, the Weight will be thereby lessened, in Proportion to the Square of the Surface; so that a Piston, half an Inch in Diameter, sustains but a fourth Part of the before-mentioned Weight, or only four Pound; but, as when the Piston is small, the Strokes must be many more in Number, this Weight tho' lessened, must be often repeated, which causes a Dislike in People to these Pumps after all; especially, if we add to this, that the Expence of a single Barrel Air-pump, with its proper Apparatus, is nearly as great as that of a double barrelled Pump, of the portable Form you here see.

Euphros. It was on this Account then, I presume, that we have the Invention of the single barrelled Pump, you here recommend. I should be glad to know what are the particular Advantages of this Construction, and the Principles on which they depend.

Cleon. The principal Design in this Pump, is to render the Weight of the Air insensible on the Hand in working; for which Purpose, you see a Valve is provided in a Piece fixed to the upper Part of the Barrel, and a Collar of Leathers, thro' which the Shank of the Piston passes in a Piece, screwed on upon the Top of the Barrel. The Effect of this Valve is twofold; for

for, first, it gives a Passage for the Air out of the Barrel; and secondly, prevents any Pressure of the outward Air upon the Piston in the Pump, excepting what lies upon the small Hole in the Valve, which is altogether inconsiderable and imperceptible; and farther, as the Air cannot return by this Valve, so neither can it get thro' the Brass Piece in which the Piston moves, by reason of the Leathers sitting very close about it, and well supplied with Oil, which, at the same Time, by no means prevents a free and easy Motion of the Piston: This Contrivance of a Collar of Leathers, you will observe in the Course of our Experiments, will be of necessary and frequent Use in many other Cases of a like Nature. Besides these Particulars, there are some other Improvements which the Author of this Contrivance has made in the Structure and Apparatus of an Air-pump; so that those who chuse it may exhaust the Air from any Vessel, as far as the Power of Mechanism, and the Nature of Air will permit.

Euphras. But how do you find in what Proportion the Air is exhausted from any Vessel placed on the Pump?

Clem. By means of a Gage, which is provided for that Purpose, of different Forms, according to the different Kinds of Pumps that are used. This Gage consists of a Glass Tube, immersed in a Bason of Quick-silver, in the large * Air-pump. This

* The most elegant Form of this Pump we have thought proper to give a Print of, for the Sake of explaining the several Parts of which it consists, which are the following:

a a, The two Brass Barrels of the Pump.

b b, The Handle, or Winch, by which

c c, The two Pistons are worked in the Barrels.

d d, A Brass Elliptic Bason, which was formerly in Use for holding Water to supple two Leathers in the lower Part of the Bason, but is now disused, as not necessary.

e e, Two ornamental Pieces of Wood, by which

f f, The Head of the Pump is screwed very fast down upon the Barrels.

g g, The two Pillars supporting the same.

h h, A long Pipe, by which the Air passes from the Receiver into the Barrels.

i i, The Brass Plate, on which the Receivers are placed, to be exhausted of their Air.

k, The Hole in the Middle of the said Plate.

l l, The Mercurial Gage.

B b b 2

m, The

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This Tube communicates, on the other End (by means of a Piece of Brass) with the Hole in the Plate on the Top of the Pump; and consequently, with the Receiver, placed over it; so that, when the Air is drawn from the Receiver, it is, at the same time, taken from the Glass Tube, or Gage; and as the Spring of the Air, within the Gage, is by that means lessened, the Pressure of the outward Air becomes greater, and forces the Quick-silver up in the Tube; so that, as the Quantity and Spring of the Air is lessened in the Receiver, the Quick-silver rises higher and higher in the Tube, and could the Air be entirely exhausted, the Mercury would be just as high in the Gage, as it stands at that Time in a common Barometer; and to convince you of this, shall be the first Experiment on the Pump.

Euphros. This will give me great Pleasure. Pray proceed to the Operation.——I suppose the Divisions on the long Slip of Wood are so many Inches, by which you measure the Rise of the Quick-silver.

Cleon. That is the Use of it.——To prevent the Air from getting into the Receiver, I first place this wetted Leather on the Plate of the Pump, with the Hole in the Middle of it, just upon the Hole of the Plate. Then I take the small Receiver, and place on the Leather over the Hole.——I turn the Winch, and raise the Piston from the Bottom of the Barrel towards the Top, and you see the Quick-silver immediately rise in the Gage.——I turn the Winch back, and the other Piston rising, draws out more Air, and makes the Mercury rise still higher.——I proceed in the Operation, and each alternate Stroke of the Piston advances the Quick-silver still higher and higher; till at last,——I move the Pistons many Times up and down, without the Mercury sensibly rising any higher.——Whence you may conclude, that the Air is drawn out of the Receiver and Glass Tube, as far as the Pump can do it.

Euphros.

m, The Basin of Mercury, in which it is immersed.

n, The Stop-Cock, by which the Air is let into the Receivers again.

These are all the essential Parts of the Pump necessary to be described; the Apparatus proper for Gentlemen's Use we shall exhibit in a Plate hereafter.

Euphros. I observe the Motion of the Quick-silver rising with every Stroke of the Piston, with the highest Satisfaction ; and by this one Experiment only, can see a great Way into the Nature and Use of this curious Engine. But what is the Form and Rationale of the other Gage you mentioned ?

Cleon. I will tell you, and shew its Use by an Experiment also.——It consists of a short Tube, hermetically sealed at one End, filled with Quick-silver, and inverted with the open End into a small Bason of Quick-silver, and then placed on a small Plate, communicating with the common Duct of the Pump, as you here see it on the portable Air pump.

Euphros. I see it indeed, but I do not rightly understand it.——It seems to me, as if this Gage was to shew how far the Air was exhausted by the Motion of the Quick-silver downward.

Cleon. You judge very rightly ; for, as the Air is drawn out of the Receiver, it is, at the same Time drawn out of the Glass, placed over the Gage ; and consequently, the Spring of the Air on the Quick-silver in the Bason being constantly diminished, it will at length become less than the Weight of the Mercury in the Tube, at which Time the Mercury will begin to subside ; and as the Operation of the Pump is continued, it will sink lower and lower, till at last, it will stand but a very small Height above the Surface of that in the Bason : Whence, likewise, we shall know, that the Air is drawn out as far as it can be.

Euphros. I perfectly understand you.——But one Thing I must observe, that you several Times hinted, that the Air cannot be wholly exhausted from the Receiver.——Pray, give me the Reason for that.

Cleon. You will easily perceive the Reason of it, when you consider, that, tho' the Quantity of Air be diminished by each Stroke of the Piston, and its Spring thereby continually lessened ; yet, if the Operation of the Pump were to be continued ever so long, the Consequence could only be a continual Diminution of the Quantity of Air ; but a Total Exhaustion of it will be impossible, because the Piston can take away no more Air than what is forced into the Barrels by the Spring of the remaining Air in the Receiver. Therefore, after the last
Stroke

Stroke of the Piston, there will be some Air remaining, but that may be so small, as not to be capable of throwing up the Valve any longer, and therefore must remain exhaustible: But these Valves and Gages have been so ingeniously contrived and improved, that the Quantity of Air may be exhausted to much less than the thousandth Part of the Whole; and there are not wanting a few among the Wealthy, who have been liberal enough to encourage this Species of Ingenuity to the utmost Extent of Art.

Euphros. Were I among the fortunate Number, where Affluence exceeded the necessary Occasions of Life, so far as to put it in my Power to have what I can wish, I would not only have an Air-pump, but every other philosophical Instrument that the Improvements of the present Age could supply.

Cleon. This would be making a proper Use of the Gifts of Fortune, and doing Good with the best Grace and Taste; it would be happy for Artists and Tradesmen, if more of the Opulent were found of that Disposition.——But Others must be provided for, and Pumps of the common Form and easy Price will answer all our Purposes very well; as you will perceive by a Series of Experiments on the portable Air-pump, which I shall next proceed to exhibit.

Euphros. I long till you make a Beginning; as from what I have already seen, I promise myself not a little Pleasure and Improvement by them. You have already shewn me one Experiment, and I want to see what will be the Subject of the Second.

Cleon. For the second Experiment, I take this small Glass, and place over the Hole of the Pump, as before, and when I have worked the Pump,——you perceive the Weight of the Air in a visible Pressure of the Glass into the wet Leather.——I soon exhaust the Air: The Quick-silver you see at 29 and $\frac{1}{2}$,——and now, if you try to pull the Glass up, you will be still further convinced of the Weight of Air in pressing it down;——Try what you can do.

Euphros. I will——but it sticks so fast that I cannot.——Sure! It can never be the Weight of the Air that keeps it thus fast upon the Pump.

Cleon.

Cleon. It certainly is, and nothing else; you must consider, the Surface of this Glass is about four square Inches, and therefore sustains a Pressure from the Atmosphere of fifty Pounds Weight. No Wonder then, if your tender Arm should not be able to raise it from the Plate.

Euphros. Have you any Experiment by which you can prove this to be owing entirely to the Weight of the Air?

Cleon. Yes; that will be a third Experiment, and give you an ocular Demonstration of the Truth. — I take the same Glass, and place it under a large Receiver, and on one Side of the Hole on the Plate. — Then, when I begin to pump, if you look at the Rim of the small Glass, you will observe it will be a little lifted up from the Leather, by the Spring of the Air throwing itself out from under it into the large Receiver; especially, at a few of the first Turns of the Winch. — The Air is now exhausted far enough. — The small Glass has now but little Air within it, and is easily moved, as you see by my shaking the Pump. — But now keep your Eyes fixed on the Rim, or Bottom of the small Glass, and when I turn the Vent-piece to let in the Air, you will perceive the Weight of it will fix the Glass upon the Pump, and you will see it sink down into the Leather. —

Euphros. I hear the Air rush in, and see it fix the Glass down in the Manner you mention by its Pressure. — A curious Experiment this! and a full Proof of all I desire to know; for now you have taken the larger Glass away, I find it as fast on the Pump, and just as immoveable by my Strength as before. — These Experiments make the Weight of the Air sensible to a surprising Degree.

Cleon. And you will have more Reason to think so from the next Experiment, in which you will be a Party concerned; for you are now to lay your Hand on this open Glass, placed over the Hole of the Pump. —

Euphros. Not I, truly; I am too well convinced of the Force of its Pressure, without any farther Experience of the Matter.

Cleon. You need not be afraid, my *Euphrosyne*; you may be assured, the Experiment is innocent; and I will put my own Hand on the Glass first for your greater Satisfaction. — You observe,

observe, I lay on the fleshy Part of my Hand, and work the Pump with the Other. ——— You see the Flesh on the Back of my Hand sensibly pressed down between the Bones, by the Weight of the Air : ——— And below, within the Glass, you as plainly perceive how the Flesh of my Hand is protruded, or forced down into the Glass, by the Spring of the Air contained in it.

Euphros. Yes, I see all that you mention, and wonder how you could ask me to try such an Experiment, which gives me so much Pain to see it performed by Another. ——— I should fear lest it should maim my Hand, by bending it into the Glass. Pray, take your Hand off, *Cleonicus* ; for it has a very disagreeable Appearance. ——— The Blood is ready to start thro' your Flesh into the Glass.

Cleon. This last Circumstance, which you mention, shews the Reason why Surgeons take this Method in Cupping, or Scarification ; for they take a small Glass, fix it over the Part from whence they intend to take the Blood, and with a small Syringe, screwed on the Top of it, they draw out the Air from the Glass. The Air contained in the Flesh below puffs it up into the Glass, and the Blood flows in great Plenty towards that Part ; and consequently, thro' the several little Orifices made before by the Scarificator.

Euphros. It is to answer the same End, I suppose, that I have seen some hold the Cupping-Glass over the Flame of a Lamp, and then immediately apply it to the scarified Part.

Cleon. It is so ; and one would scarcely think what a Quantity of Air the Flame will instantly expel from the Glass, and thereby fit it for the Purpose. ——— But to return from this Digression ; you must not think to come off without laying your Hand on the Glass ; and because you shall not be afraid, I have provided one of a less Size. ——— I will also cease working the Pump, whenever you desire me to do it.

Euphros. I am very timid, and yet have some Inclination to try the Experiment, as I love to be convinced of the Truth of Things by all the Means of Sensation. ——— But be sure work the Pump very gently.

Cleon. That you may depend on ; therefore put on your Hand so close that no Air can get under it into the Glass. ———

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I give one Turn of the Winch, and you find a sensible Pressure on your Hand, and swelling of the Flesh within the Glass.

—— A second Stroke renders this still more sensible; —— by the Third ——

Euphros. —— Oh! *Cleonicus*, remember your Promise, and stop the Pump; for my Hand is so sucked in, that I am not able to bear it any farther. It is fixed so fast down, that I cannot remove it. ——

Cleon. You cry out before you are hurt. —— I must give you one more Turn of the Winch. —— I don't mind your Panic, it cannot hurt you; therefore you must have another Stroke yet. ——

Euphros. I beg you will proceed no farther. If you do, I shall not think you regard me with the Tenderness of a Brother. —— How shall I do to get my Hand off? —— Pray, disengage me immediately.

Cleon. I shall instantly release you from this philosophical Thralldom which you seem to be in. —— You have not Half the Courage of some of your Sex, whom I have seen sustain the whole Weight of the Air upon their Hand on a wider Glass than this, without any Out-cry at all: —— But I turn the Stop-cock, and you find no more of the Weight of the Air without, nor the Spring within your Hand.

Euphros. I am glad I am once more at Liberty, and must confess, I am not so much of a Heroine as not to be fearful in such Cases, where I know Danger may attend an Enterprize, and at the same Time know not when, or how it may begin. —— I make no Doubt, but you find Gentlemen as timorous as the Ladies in this Respect.

Cleon. I will not say they are more so in general; only this I will assure you, I have found many a one whom I could not prevail upon to lay his Hand upon the Glass, by all the Importunity I could use.

Euphros. Well! It makes my Hand affected with an odd Sensation. —— How red the Part appears, with the Circle of the Glass impress! But enough of this. —— Pray, what is your next Experiment? I hope you have nothing farther for me to do.

C c c

Clay.

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Cleon. By the next Experiment, you will further perceive the wonderful Weight of the Air, as it will burst this Bladder, which you see tied over the large, open Glas.

Euphros. I suppose you mean, that, when the Air is taken away from the Inside, the Weight of the Air without is so great on the Bladder, as to break its Way through it into the Glas.

Cleon. That, you will see, will be the Case.—— I place the Glas on the Pump, and with one Turn of the Winch only, you see how the Bladder bends down.—— With a second Turn, it descends still lower.——

Euphros. Well! This is a very curious Appearance! The Bladder seems perfectly hollow, like the concave Surface of a hollow Globe.——

Cleon. You happen to hit off the Matter exactly; for there is a physical Demonstration, that the Concavity of that Bladder, resulting from the Pressure of the Air, must be truly spherical.—— But now expect the Consequence of a greater Pressure, which will more immediately affect your Ears than your Eyes.—— I give another Turn or two, —— and the Bladder bursts with the Report of a Gun.

Euphros. I imagined I should hear it; but little thought of a Sound so great. I assure you, I should have stopped my Ears, if I had; for it has almost made me deaf.—— Pray, what Weight do you think there might be on the Bladder?

Cleon. The Glas is four Inches in Diameter; there is therefore four times four, or sixteen times the Weight of the Air on the Bladder, as there is in one circular Inch, which, as I have observed to you before, is 12 Pounds; so that the Whole is 12 times 16, or 192 Pounds. No Wonder, therefore, if the Bladder breaks with the Pressure of near 200 Weight.

Euphros. Such Experiments as these naturally tend, by Degrees, to abate the Wonder we usually express at some mighty Effects we observe produced by those invisible Agents, the Weight and Spring of the Air.

Cleon. They do so, to see a huge Fire-Engine, worked by one, and the largest Bomb-shell burst by the other, create Wonder and Amazement in vulgar Minds; but, when viewed with a philosophical Eye, they appear to be no other than the ordinary

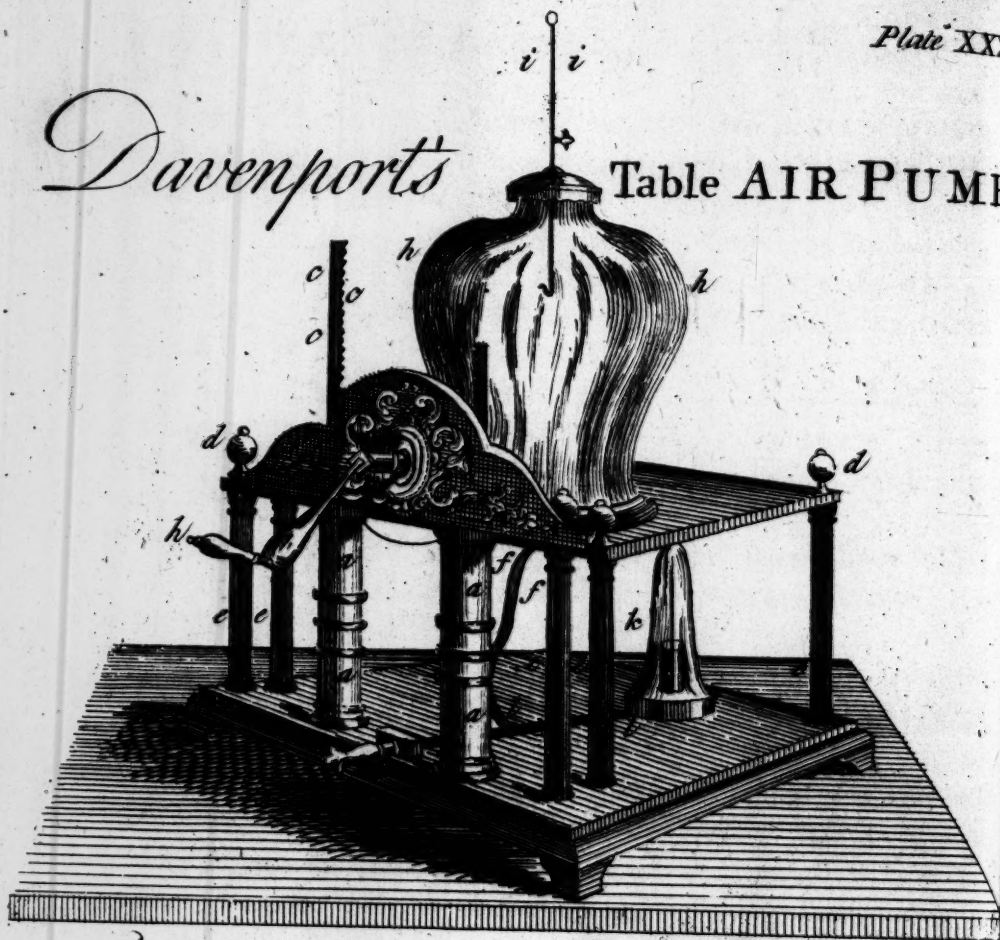
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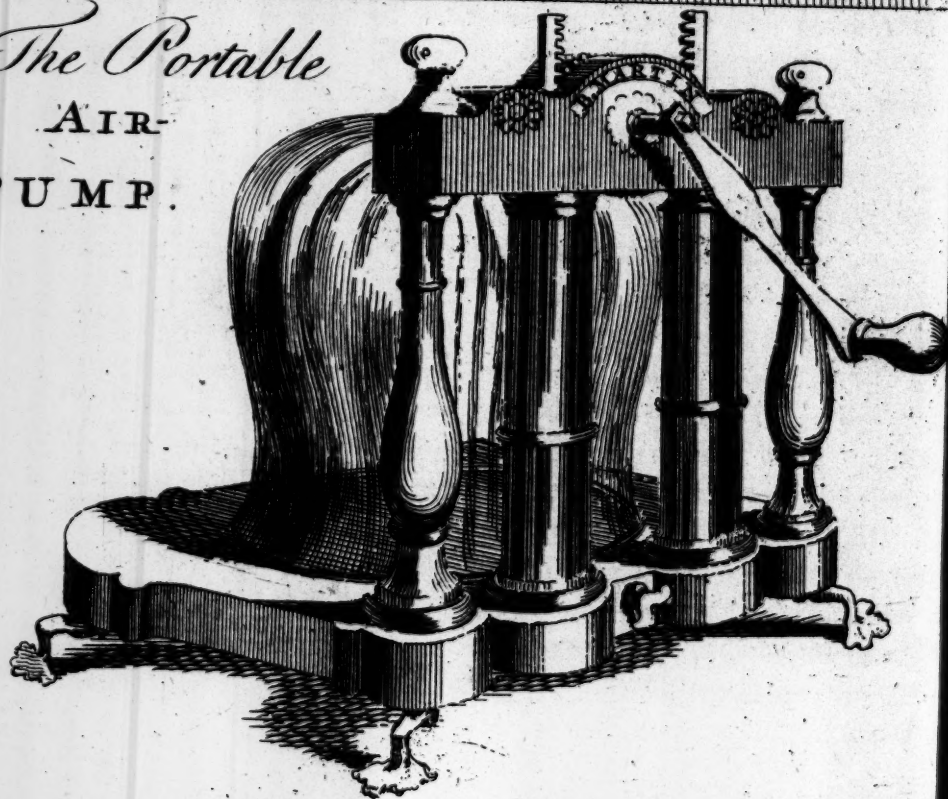
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Table AIR PUMP



The Portable
AIR-
PUMP.



ordinary Effects of natural Causes. — The following Experiment will shew you how naturally the Air will throw itself out, by its Spring, from any Vessel in which it is contained, when the Pressure of the external Air is taken away; for which Purpose, you see here, a small, hollow Globe of Glass, with a long Neck to it. — This Globe, I place on another Glass, partly filled with Water, and the Neck immers'd therein nearly to the Bottom. This I place on the Pump, and a close Receiver over it. — Now I turn the Winch, and you see how prettily the Air throws itself out from the Globe, through the Water, in a Succession of numberless Bubbles, and that at every Turn of the Winch.

Euphros. See it! Yes, that I do, and with the utmost Pleasure. — I likewise observe the Reason of your placing it under Water; for else I could not have seen the Air make its Escape from the Globe. — But I farther observe, that the longer your Pump, the less is the Quantity of Air thrown out of the Globe at each Exhaustion; but the Reason of this, I recollect, you explained to me heretofore; consequently, cannot expect to see the Air entirely exhausted from the Globe.

Cleon. I have nearly exhausted the Air, — and when I turn the Stop-cock to let the Air into the large Receiver, it will necessarily fall on the Surface of the Water, and by its Pressure drive it up into the exhausted Globe. — You see the Effect instantly produced.

Euphros. It rushes with great Violence into the Globe, indeed, and almost fills it. — The Bubble of Air, which I see on the Top, is, I presume, that which remained in the Bulb, after Exhaustion, and is now condensed into a small Space.

Cleon. That is really the Case; and you see by that, how small the Quantity of remaining Air, compared with the Whole, at first contained in the Globe, or to the Bulk of Water now in it, which must be equal to the Quantity of Air drawn out; and in common Pumps, it is about the rooth Part of the Whole. — And we see, in this Experiment, that the Spring of the Air, in any Quantity, is equal to the Weight of it, by producing an equal Effect; for while the Spring of the internal Air was less than the Weight of the external Air, the Wa-

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ter kept rising in the Globe; but, when the Spring at last became equal to the Pressure, the Water subject to both their Influence, and finding it equal on either Side, could no longer move.

Euphras. This is a plain Demonstration of a very important Proposition, as I take it.——But how do you get the Water out of the Globe again?

Cleon. By a Process just the Reverse of the former Experiment.——Now I take this small Glass-jar, and placing it on the Plate of the Pump, I invert the Bottle of Water upon it, and covering the Hole with the Receiver, I begin to exhaust,——and you observe, that no sooner the Winch moves, but the Water begins to descend thro' the Neck of the Bottle.——It drops only at first; but, as the Motion of the Pump is continued, the Motion of the Fluid is accelerated, and at Length it runs in a continual Stream.——This Stream likewise is accelerated, till, at last, you see it all run out, and with the same Number of Turns of the Winch as before were made to fill it.

Euphras. This is a very entertaining, as well as instructive Experiment; for by this, I see, that the Weight of Water sustained is always proportioned to the Spring of the Air. As the Latter is lessened, the Former must be so of Course, till the Spring of the Air within becomes equal to that without. When the Weight of the Water becomes nothing, and consequently must be all run out.——Thus far I have been able to understand the Nature of this Experiment. Pray, what Use do you make of it, *Cleonicus*?

Cleon. To shew the Reason of another similar Experiment with an Egg, which I have here provided for that Purpose; for, if I make a Hole in the little End of this Egg, and place it with that End downward, as I did the Jar, with the Bubble of Water before,——You observe, that as soon as I turn the Winch, the White of the Egg, and the Yolk are both protruded thro' that Hole, and the Egg becomes entirely empty.

Euphras. Indeed, I do observe it with very great Pleasure, and one would think, there must be a Bubble of Air in the great End of the Egg, like what we had before in the Bottle, to
con-

contribute, by its Spring, to the Expulsion of the Contents of the Egg.

Cleon. You have just hit upon the Thing. There really is such a Bubble of Air in the great End of every Egg, and as it is contained between the Shell and the Skin of the Egg, we shall have an Opportunity of shewing it, by an Experiment in a very curious Manner. Thus ——— I take away with a Pen-knife near Half the Shell of the Egg, and then placing the other Half upright, on the great End, that you may see all the internal Part, I place a small Glass over it, ——— and turning the Winch, you see the Skin begin to rise from the Bottom. ——— As I continue to work the Pump, you see the Effect of that Bubble of Air manifestly, by raising the Skin still higher and higher in the Egg. ——— You now see the Skin up to the Top of the Egg. ——— You see it rises still higher and higher, and puts on the Form of that Part of the Egg which is taken away; so that now the Skin of the Egg on one Part, and the Shell on the other, make the Egg appear, as it were, again compleat.

Euphros. A wonderful Spectacle this, and what I should never have thought of, if I had not seen it! ——— Indeed, I have often observed, in boiling of Eggs, that there was always a hollow Part in the great End between the coagulated White and the Shell; and further, I have often wondered, that the Shell should so readily come off at the great End of such an Egg, but should adhere to, and be with Difficulty separated from the White at the little End.

Cleon. You have heard of the old Adage, ——— *There is Reason in roasting of Eggs.* ——— That very Reason, which you now see in boiling them, is all contained in this Bubble of Air; and this only one Instance, out of many, of culinary Philosophy; or that which concerns Cookery, which, therefore, shews it to be an Art, which is not only necessary in Life, but ornamental in your Sex; as it is in every Part founded on the nicest Principles of natural Reasoning, and therefore worthy the Study, if not the Practice of every young Lady; and I have the Pleasure to know, that, for your Part, you excel in both.

Euphros. You say a great deal, *Cleonicus*; I know your Partiality to me. ——— I know but little, at present, of the Philosophy

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Philosophy of any thing ; but I must own, that which concerns my own Business more immediately delights me ; and in this, I am but like other People ; for every one is delighted to see the Reason of what he likes. —

Cleon. Nor have we yet taken Notice of the principal Thing discovered by this Experiment. — For hence we learn, that this Bubble of Air is the Means which Nature has appointed for the Maturation, and bringing to Perfection the Chicken contained in *Embryo*, in what we usually call the *Treadle* of the Egg. This is done by the constant Incubation, or Setting of the Hen upon the Eggs. For by the Warmth, thus communicated to the Air, the Spring of it is increased somewhat beyond its natural Tenour ; and, at the same Time, its Parts are put into Motion by this gentle Rarification. Hence Pressure and Motion are communicated to the Parts of the Egg, which, some how or other, does gradually promote the Formation, and Growth of the Chicken, in the appointed Time of its Exclusion, or Hatching. — This also is an Article of natural Knowledge, which will not sit ill upon the Understanding of the good House-wife, who delights in the Breeding of Fowl.

Euphros. Indeed, I think so too ; and every Time I see a Hen sitting, I shall be apt to recollect this Part of the present Lecture on Philosophy. — It will be hardly worth while, after the mention of Things of such Moment, to speak of that common Experiment, of putting one's Tongue to the great End of the Egg, to find if it be warm ; the Reason of which, I suppose, is also contained in this included Air.

Cleon. It is so ; nor is this Experiment to be passed over without Notice, as it is the Criterion by which we judge of the Goodness of the Egg ; for, when the great End of the Egg feels cold to the Tongue, it is a certain Proof of the Egg's being bad ; for the Air having made its Escape by Degrees thro' the Pores, or otherwise, the Egg becomes stale, and at Length, grows putrid, or addled. — We have long dwelt on the Subject of Eggs, and have not yet done with it neither ; but before we can proceed any farther, some other Experiments must be premised.

Euphros. Pray, what is the next Experiment, *Cleonicus* ?

Cleon.

Cleon. Experiments which next are to shew, that Air is plentifully contained in all Kind of Bodies, both fluid and solid, tho' we see it not, and therefore think little of the Matter. — For the first Experiment of this Sort, I shall put clear, cold Water into this tall, Glass-jar, and placing another over it, I turn the Winch, — and you see the Appearance of Bubbles of Air thro' the Body of the Water. — They appear very thick, but small. — They now grow larger, and rise to the Top of the Water. — They are now very large, but less in Number. — And as long as the Pump continues to work, so long you see the Air arise from the Bottom of the Water to the Top, but more slowly, and by Bubbles of a larger Bulk.

Euphros. Well! this Pump is a most wonderful Machine! Every Experiment adds an Increase of Knowledge. — I could not have thought there had been so much Air in Water, had I not seen it thus demonstrated; and thus, I suppose, Air may be contained in other Fluids as well as Water.

Cleon. In the very same Manner, differing only in Quantity; some containing more, others less. However, one Circumstance must be attended to in spirituous Liquors, where something more than mere Exhaustion by the Pump contributes to the Rarification of the Air contained in such Fluids; as you may observe, by the following Experiment, — I take the Jar of Spirit of Wine, cover it, and exhaust as before. — And now you see how suddenly the Air-bubbles shew themselves; — how violently they rush to the Top, and burst: Nay, you observe a perfect Ebullition in the Spirit, by the excessive Rarification and Expansion of the Air.

Euphros. The Spirit perfectly boils, like Water on the Fire, and now I begin to see a little into the Nature of Boiling. —

Cleon. You will see more, by the following Experiment, of the Nature of this great Operation of the Kitchen; for you will find, that the Pot might be made to boil with an Air-pump, as well as by Fire; but it will be but for a little Time only. — For now I fill the same Jar with hot Water, put it under the Receiver, and exhaust; — and you see numberless Bubbles immediately appear. — I turn the Winch a second Time, and they become large, and rush towards the Top. —

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A third Stroke produces a great Ebullition, or Boiling of the Water, which now, you see, plainly proceeds from the Rarefaction of the Air, occasioned by the Pump, and the Heat of the Water together. And it is very observable, that, at last, you see the Air is but small in Quantity, and expands itself in very large Bubbles. The Boiling of the Water decreases by Degrees, and at Length becomes little or nothing, when the Air is nearly exhausted.

Euphros. These Experiments are so many Lessons of Instruction. I plainly perceive, that the Boiling of Water is nothing but the Agitation, or Motion produced by the Expansion of Air, and that this is occasioned by the Heat of the Fire, when sufficiently great, as in common Cases of boiling our Food, or by the Heat of Fire, and the Action of the Pump conjointly, as in this artificial Boiling, you have now shewn, and by some other Agent, I know not what, in the Boiling your spirituous Fluid.——Have you any other Experiment of this Kind for the Improvement of domestic Knowledge? ——

Cleon. Yes, many; one in particular respects the Air in Beer, which I know will please you, and therefore shall next shew it.——Beer, just tapped, or new, is fittest for this Purpose; such as you have in this Decanter. —— I fill the Jar Half full, and put it under the Recipient. —— I no sooner move the Winch, but you see the Beer replete with Bubbles of Air. —— Another Turn makes it almost opaque, and in Motion throughout; —— a Third makes them rise to the Top in prodigious Quantities, and these constitute a frothy, white Head. —— This becomes larger and larger, by the constant Rising of the Air, —— till, at last, it runs over the Top of the Glass.——

Euphros. Well! this is a merry Sort of an Experiment. It makes me smile, to see so odd an Effect. —— I see the Beer grow finer, as the Air is exhausted from it. —— I now likewise understand why that Beer is always brisk and pleasant that produces a frothy Head. —— And lastly, I see the Reason of the frothy Phenomenon itself, viz. that by Reason of the Viscidity of the Beer, the Bubbles of Air cannot so suddenly expand themselves as on the Top of Water; but lie one upon another in that expanded State, and make that white, and porous Body.

Cleon.

Cleon. You have given the true Reason of the Thing; and you will farther observe in this Experiment the general Reason of Transparency, and Opacity in Bodies; for the Beer is more transparent, as it contains less Air, and the Froth becomes opaque, on account of the larger Interstices, or Bubbles of Air; therefore Transparency depends on the Fineness or Smallness of the Pores, and solid Parts, and Opacity on their being large. — Thus Paper having its Pores filled with Oil, becomes much more transparent, than it naturally is, when filled with Air.

Euphros. I fancy some of those Experiments, which you shewed me, relating to the Production of artificial Air, would shew themselves to great Advantage in the exhausted Receiver.

Cleon. In this you would find yourself mistaken, were you to try them all; for the Rarefaction of the Air, in many of them, would be so violent, as to drive the Liquor out of the
D d d Vessels.

We think proper, by way of Note, to give the following Account of two Air-pumps contained in Plate the XXXth.

A Description of the Structure of Davenport's Air-pump.

a a The Brass Barrels.

c c The Pistons.

d d The Brass Knobs, which screw down the Bed of the Pump upon

e e The Pillars.

f f The Brass Pipe communicating with

b b The Receiver above, and

l l A Pipe below, from whence the Air is conveyed to the Barrels.

i i Is a Brass Wire, sliding through a Collar of Leathers, on the Top of the Receiver.

k The Mercurial Gage on the lower Part of the Pump, with which the Pipe l l also communicates.

m Is the Stop-cock, to be turned for letting in the Air.

This, together with the foregoing Description of the large standing Pump, is sufficient to shew the general Mechanism of this Machine; but as in both these, the Structure is very complicated, I have contrived one, in a much more simple and portable Form; and therefore I have called it the *Portable Air-pump*, and have shewn it, by a proper Figure, in the lower Part of Plate XXX, of which no particular Description is necessary; as the Parts of which it consists are so few, and fully described already in the other Pumps; especially, as it has been so many Years known, and approved of by the Public.

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Vessels. ——— This happens, especially in effervescent Liquors, or Acids and Alkalies mixed together. ——— Some of these Liquors being mixed in the exhausted Receiver, produce such an explosive Æther, or Spirit, as to blow up the Receiver from the Pump, notwithstanding the great Pressure of external Air upon it. ——— Such Experiments, therefore, as they are not to be shewn without Danger to the Persons present, I shall not attempt, but the following one is very innocent, and will shew the Nature of metallic Solutions more perfectly than you can see it without. ——— I take a Quantity of *Aqua Fortis*, a little warmed, and put it in a small Jar under the Receiver. ——— On the Top of the Receiver, a Brass Wire is moved up and down, thro' a Collar of Leathers at Pleasure. ——— Then, before I turn the Winch, I thrust the Wire down about an Inch into the Fluid, and a gentle Solution begins, with a considerable Production of Air; ——— but observe, when I turn the Winch, how surprisngly these Bubbles of Air increase, and what a prodigious Effervescence they occasion in the Liquor. This is only an Illustration of the general Nature of Solution, in which we observe the Body is resolved into two Parts, *viz.* its own metallic Part, and a large Quantity of Air.

Euphrosi. But the Air which I now see is the factitious, or generated Air, from the Body itself. — The Air contained in the Pores of solid Bodies is likewise rendered visible, I suppose, as you intimated just now.

Cleon. It is very easily extracted, and shewn this Way, by placing the Body under Water. ——— Thus I take this Piece of Free-stone, and a Piece of Brass, and put them both in the Water of the Jar, and by pumping the Air out of the Receiver, it rises by Degrees from the Pores of those Bodies; and when I have pumped long, the whole Surface of the Brass and Stone is nearly covered with those pearly Bubbles of Air, which make a very curious Appearance; and the like you would observe from any other common, earthy Substance.

Euphrosi. As also, I suppose, from any animal, or vegetative Substances.

Cleon. They contain much greater Quantities of Air; some Specimens of which, I shall now give you. ——— I take this new-laid Egg, and put it in the Jar of Water under the Receiver

ceiver, and upon turning the Winch,——you see many fine Streams of Air rising from the Pores of the Egg. —— As I continue to work the Pump, you see many more of these ærial Jets arise.——Observe now the Pores of the Egg emitting the Air in innumerable small Bubbles, which gives it a very pleasant Appearance.——After this, as the *Vacuum* proceeds, you find the Egg expanded by the Rarification of the internal Air, so as to be rendered specifically lighter than it was. —— You see it move, and roll about, and seems, as it were, to endeavour to rise to the Top, and is therefore but very little heavier than Water. —— I turn the Cock, and let the Air in, and you see the Streams and Bubbles all disappear at once.

Euphros. These Things are extremely entertaining. I could not have imagined there could have been so much Air contained in an Egg, or, that there had been such evident Pores in the Shell.——I suppose, that, in like Manner, if a whole Animal were to be immers'd, one might see the Air issue from the Pores of his Skin.

Cleon. That may be easily experimented in a small Bird, plucked of its Feathers, and put under Water.——In vegetable Substances of every Kind these Experiments shew a surprising Quantity of Air, as I shall instance in this Apple, that is just now gathered from the Tree.——I connect it with a Piece of Brass, and sink it to the Bottom of the Water, having first made a few Holes in it with a Pin.——Then I cover it with a Glass, and as I begin to exhaust, you see the Air arise from the different Parts of the Apple, but particularly from the Holes made with the Pin.——As I further proceed, you see the Air rising from the Pores of the Apple in many sensible Streams. —— As the Air is still farther rarified, the Streams are more and more numerous, and the Quantity of Air so great, as to make a perfect Ebullition on the Top of the Water. —— If the *Vacuum* remain for any Time, you will see the Bubbles and Streams of Air continue so long, —— and if you look at the Gage, you will see the Mercury sink in Proportion to the Air, produced from the Apple, and this as often as the Experiment is repeated. —— At last I turn the Vent-screw, and the Air disappears at once.

Euphros. This is a noble Experiment, truly ! and I fancy, from what I have now observed, that a shrivelled Apple would also make a very pretty Appearance in the Water.

Cleon. It will, indeed ; and I usually shew the Experiments on both, when they can be had,——I have a withered Apple of the best Kind for this Purpose, which I shall now put into the Water, and you will see the Difference between this and the other,——When turning the Winch, you see many Streams of Air arise, tho' not so large and numerous as before ; but you observe, at the same Time, the Effect of the internal Air, by expanding the Apple, and causing the Wrinkles to disappear by Degrees,——till at last, it has attained to the full Extent of its Skin, and looks nearly as full and fresh, as when first gathered from the Tree.

Euphros. By this Experiment and the Former, I am thoroughly convinced of the Nature and Difference of Fruit, with regard to the Air they contain. I see from thence, how pervious they are to this necessary Element. I learn too from hence, how necessary the Air is to preserve them, and to give them that Poignancy and pleasant Flavour, which they have when recent or fresh gathered ; and that Mellowness, and Rottenness, proceed, from some Deficiency either in Quantity or Quality of the Air in Fruit of the last Year's Growth.

Cleon. You reason very well on the Experiments you have seen ; but, by another Experiment or two that will follow, you will find, that Fruit of any Kind is best preserved without any Air at all ; and that it is the constant Action of the Air that destroys the natural Texture by an incessant and insensible Fermentation in the Parts, which disposes them, by very slow Degrees, to become putrid, or rotten.

Euphros. If this be the Case, one would think Methods might be contrived, by Means of your Pump, to keep the Fruit from the Air as long as you please, which would be a fine Improvement for the Pastry-cooks, in regard to their Tarts and Pies.

Cleon. It would so ; and in an Age or two more, our Posterity may wonder how it came to pass, that the great Philosophers of this Age should shew so bad a Taste, and be content with discovering the Means of living well, but leaving them to enjoy

enjoy it. You will find Mr. Boyle's Works abound with Instances of this philosophical Method of preserving Fruit; many of which, if we may judge from his Experiments, far exceed the poor Provision of Pickles and Confections.

Euphros. You make me very attentive to what you now say. This is a very interesting Point with me, and I must insist upon your being extremely particular in gratifying my Curiosity and Enquiries upon this Head; and, in the first Place, pray, tell me how you proceed in this Affair of preserving Fruit.

Cleon. For this Purpose, we have Glasses, blown of a proper Form, to hold a Pint, or Quart, or any Quantity you please, of any Kind of Fruit; as Peaches, Nectarines, Apricots, Apples, Pears, Plumbs, Cherries, Gooseberries, Currants, &c. The Mouth, or Neck, of these Bottles is therefore larger or smaller, in proportion to the Size of the Fruit you intend to preserve, and their Form must be conical, or tapering inwards.——In the next Place, Corks must be nicely fitted to the Orifices of these Glasses. Then, having filled the Bottle with Fruit, clean and dry, you put in the Cork, and tie a wetted Bladder over it, so that, when dry, it may firmly adhere to the Cork and the Glass, and by this Means render the whole Air-tight.——After this, you place Sealing-wax on one Part of the Cork, and with a red hot Iron Wire burn a Hole through the same, that thereby a Passage may be given for the Air to be drawn out from the Fruit.

Euphros. Such an Experiment I should be extremely glad to see. Have you got any such Glass by you, *Cleonicus*? If you have, I can supply you with Fruit.

Cleon. I have several of them, and your Garden produces some of the finest Fruit to be preserved in this Way. A few of your Nectarines and Peaches, gathered dry, will suffice for an Experiment at present, and afterwards you may make use of this Procedure for any other Sort or Quantity of Fruit you please.

Euphros. I will, this Minute, step into the Garden.——Did you ever see finer Fruit?——Where is your Glass? Have you one that will take any Fruit so large?

Cleon.

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Cleon. This one will do it, and was made for receiving this Sort of Fruit. What you have brought are fine indeed; but you will find, that the Age of Fruit will little appear in their Countenance in *February* next.——You observe, I carefully put them into the Glass till it is filled:——Then, this Cork, prepared, readily fits the Top of the Recipient, which I press down very hard.——Then, with this ignited Wire, I burn a Hole through the Sealing wax and Cork; and here I must cease from pursuing this Experiment any farther at present; the Sun must lend us his Aid, and co-operate in the ensuing Part. Besides that, I have already tired your Attention with so long a Lecture. To-morrow, if the Morning be clear, as soon as the Sun-beams enliven the Parlour, I shall then wait on that glorious Luminary and yourself; so at this Time, Adieu.

DIALOGUE XII.

The Experiments on the AIR-PUMP continued.

Euphrosyne.

THIS Morning answers to my Wishes; the glorious Sun promises Success to our Designs, and the Entertainment you gave me with the preceding Experiments, have greatly excited my Expectations for the Remainder; but none takes with my Curiosity so much, as the *Experiment* under Consideration.——I see here stands the Bottle with the Fruit still.

Cleon. Yes, and in a few Minutes time the Sun will dart its Beams into the Room.——This convex Glass will converge the Beams of the Sun into so small a Compass, as to make them burn any combustible Object that is placed in the denser Part, or the Focus in the Rays.——Thus, you see, I hold the Glass in the Sun-beams, and a Piece of brown Paper in the Focus.——You see it begins to fume,——and immediately kindles into a Flame.

Euphros. A surprising Experiment indeed! The Heat that sets that Paper on fire, will certainly melt the Wax on the Cork, which now, I presume, you are ready for.

Cleon.

Cleon. I waited only for the Sun, and now I take the Pump, and place it in its Beams,——and exhaust the Air from the Fruit.——Then, with the Glass, you see, the Sun-beams are easily thrown on the Wax, which instantly melts, and closes up the Hole;——and now is your Fruit prepared for keeping at your Pleasure.

Euphros. I thank you, *Cleonicus*, for this. I shall set it by, with an Intent to prove how far your philosophical Discoveries can be applied to improve those natural Delicacies of Life.——I am afraid I have detained you too long with this Experiment. Pray, what have you next to follow?

Cleon. As these Experiments are designed to illustrate the Properties of natural Bodies, with regard to Air, I shall now entertain you with one or two more, about vegetable Substances; and you must know, that Plants are organized Bodies, or consist of Vessels, of different Kinds, for circulating Fluids from the Earth and Air, through all the Parts; for they, no more than Animals, can subsist without a constant Respiration of Air.——Many Experiments we shall hereafter shew, to demonstrate this; but at present shall entertain you with one or two on the Pump.——You see, I have a long Piece of Wood, fixed into a Socket of Brass:——This I place on the open Receiver, so that the lower End is immersed in a small Jar of Water,——and exhausting the Air from the Surface of the Water, you see how plentifully it rushes through the Vessels of the Wood to supply the Deficiency.——I put my Thumb on the upper Part of the Wood, and you see no more Air appear through the Water.——When I take off my Thumb, you again see the Air rushing through the Pores of the Wood into the Water; and thus alternately, as I put my Thumb on or off.——By this Experiment, you see, that any Piece of Wood is pervious to the Air, and that those Air-vessels run through the whole Length, or Substance of the Tree.

Euphros. This is a very pleasant Experiment, and entertains the Eye, at the same Time as it improves the Mind. I knew not before, that Air was such a necessary Article in Plants, or that they were thus constructed, to circulate that wonderful Fluid.

Cleon.

Cleon. But I have yet another Way to shew the same Thing, which, for Variety-sake, I shall next entertain you with. — I take a Piece of the same Wood, about half an Inch long, cemented in the lower Part of a hollow Cylinder of *Lignum Vitæ*, which, when placed on the Top of the open Receiver, I fill with a Quantity of *Mercury*; and now, exhausting the Air from beneath the Weight of the Air, on the Top of the Quick-silver, forces it through the Pores of the Wood, and makes it descend into a small Glass below, in the Form of a Shower of Rain.

Euphros. A most beautiful Shower of *Mercurial* Rain, indeed! my Eyes scarce ever beheld any Thing more agreeable. — It continues to rain in an uniform, steady Manner.

A tranquil Shower truly! for though I plainly see it, yet I can scarcely hear it at all. — But see, it stops at once, and all the *Mercury* disappears above the Wood. — Well! this is a thorough Demonstration of the Porosity of the Wood, indeed.

Cleon. You are satisfied in this Point by the foregoing Experiments; but what if I should entertain you with one more yet to the same Purpose?

Euphros. You will then still more delight me, and I should be glad to see so important a Doctrine established and confirmed by every Way you think proper; since every Experiment is at the same Time a new Recreation.

Cleon. The Pores of Wood, which you have already seen pervious to the Air and *Mercury*, I shall next fill with the Latter of those Fluids, — and shall shew you this Piece of Wood entirely altered, in regard to its Colour and Weight. It is now a light Substance, and will swim in Water; you will then find it heavy enough to sink to the Bottom, like a Stone. The Colour is now white; but when injected with Quick-silver, it will be changed to a darkish Hue. — To this End, I put it, under a Quantity of *Mercury*, in a small Glass, and there confine it with a Cork. — I then exhaust the Air from the Receiver, placed over it, and the Air, contained in the Pores of the Wood, throws itself out, as you plainly see from each End, through the Quick-silver. — It is now quite exhausted, and by letting in the Air again, it falls on the Surface of the Quick-silver,

silver, and forces it into every Pore of the Wood.——Here it is ; pray, take it in your Hand, and look at it.

Euphros. Well, it is strangely metamorphos'd indeed ! It looks now of a blue Colour, and is surprisngly heavy ; sure there must be a large Quantity of *Mercury* to make it so.

Cleon. There is, indeed, a great deal of *Mercury* contained in the Wood, and —— if I strike it against the Table, you see a great Quantity falls out of the Pores. —— By weighing the Wood before, and after it is injected, you will find the Weight of Silver it contains :——But what will afford you the most pleasing Idea is, to view the Wood, thus filled with *Mercury*, with this magnifying Glafs.

Euphros. A most delightful View it affords, indeed ! I see the Quick-silver in each Pore beautifully round, and shining, like so many Pearls, all over the Surface of the Wood.—— It must certainly be owing to People's not being acquainted with the Nature of these Things, that they appear so indifferent, with regard to these sublime, and rational Amusements, and substitute the low Diversions so much in vogue for their leisure-hours Employments. —— But, pray, *Cleonicus*, what mean these *Satyrs*, and other Kind of Figures, which I see at the Bottom of this Jar of Water ?

Cleon. They are intended to exhibit an entertaining Spectacle to the Eye ; for, when I place them under the Receiver, and exhaust the Air,——you observe, they gradually ascend one after another. —— First, the Bubble ascends to the Top of the Water, —— the *Satyr* turning himself about, with his cloven Foot, ascends perpendicular to the upper Regions of the Fluid.——After this, the other antique Figures begin to move, and, in their Turns, ascend to the Top of the Fluid, —— And lastly, *Lucifer*, with his Pitch-fork, ascends in the Rear, from his *infernal* Station.——

Euphros. They make a grotesque Figure, truly ! under the Surface of the Water. They seem suspended and moved, like the Puppets in a Shew : —— But I see the Magic of all these Movements plainly ; the Images, which are all of them heavier than Water, and some more so than others, and therefore sink to the Bottom of the Water ; —— but their Bodies being hollow, and filled Part with Water, and Part

with Air, thro' small Holes in the lower Part, it necessarily follows, that, when you pump the Air out of the Receiver, that in the Body of the Images will expand, and expel some of the Water, 'till, by this Means, each Image is rendered lighter than the Water; and consequently, must ascend to the Top, in that pleasant Manner we behold them.

Gleon. That is the very Thing, my *Euphrosyne*; and if I shew you the Experiment, I find, it is sufficient; you save me the Trouble of an Explication. ——— It will not be amiss, in the next Place, to shew, by Experiment, that the Medium of Air does neither help nor hinder the attracting Forces of Bodies one upon another; which I shall prove in the three different Cases of Magnetism, Electricity, and the Attraction of Cohesion. ——— And first, I place this small Compass and Needle under the Receiver; ——— then, by applying one End of the Magnet,

An Explanation of the Figures, representing the Experiments of the Air-pump, in Plate, No. XXXI.

Fig. 1. Shews a small Glass, fixed upon the Plate of the Air-pump, by the Weight of the Air.

2. The Glass Bubble, exhausted of Air, and filled with Water.

3. The same Bubble, having its Water exhausted, and afterwards filled with Air.

4. The Air, in the great End of an Egg, driving the Yolk out of a Hole at the little End.

5. Half the Egg-shell taken off, to shew the *Putamen*, or Skin of the Egg, raised up and protruded from the Egg, by the Expansion of the Air within.

6. The Air-bubble copiously ascending thro' the Water, from the Pores of the Egg.

7. Shews the Air, arising from the Pores of an Apple, sunk to the Bottom of a Jar of Water.

8. Shews a Bladder, which at first contained but very little Air, and its Neck fast tied, expanded by the Spring of the internal Air, nearly to its full Dimensions.

9. Shews an empty Bladder, sunk to the Bottom of a Jar of Water, by a Weight, which is afterwards raised to the Top, by the Expansion of the Air in the Bladder.

10. Shews the Reason of Cupping, by placing the Hand on the Top of an open Receiver.

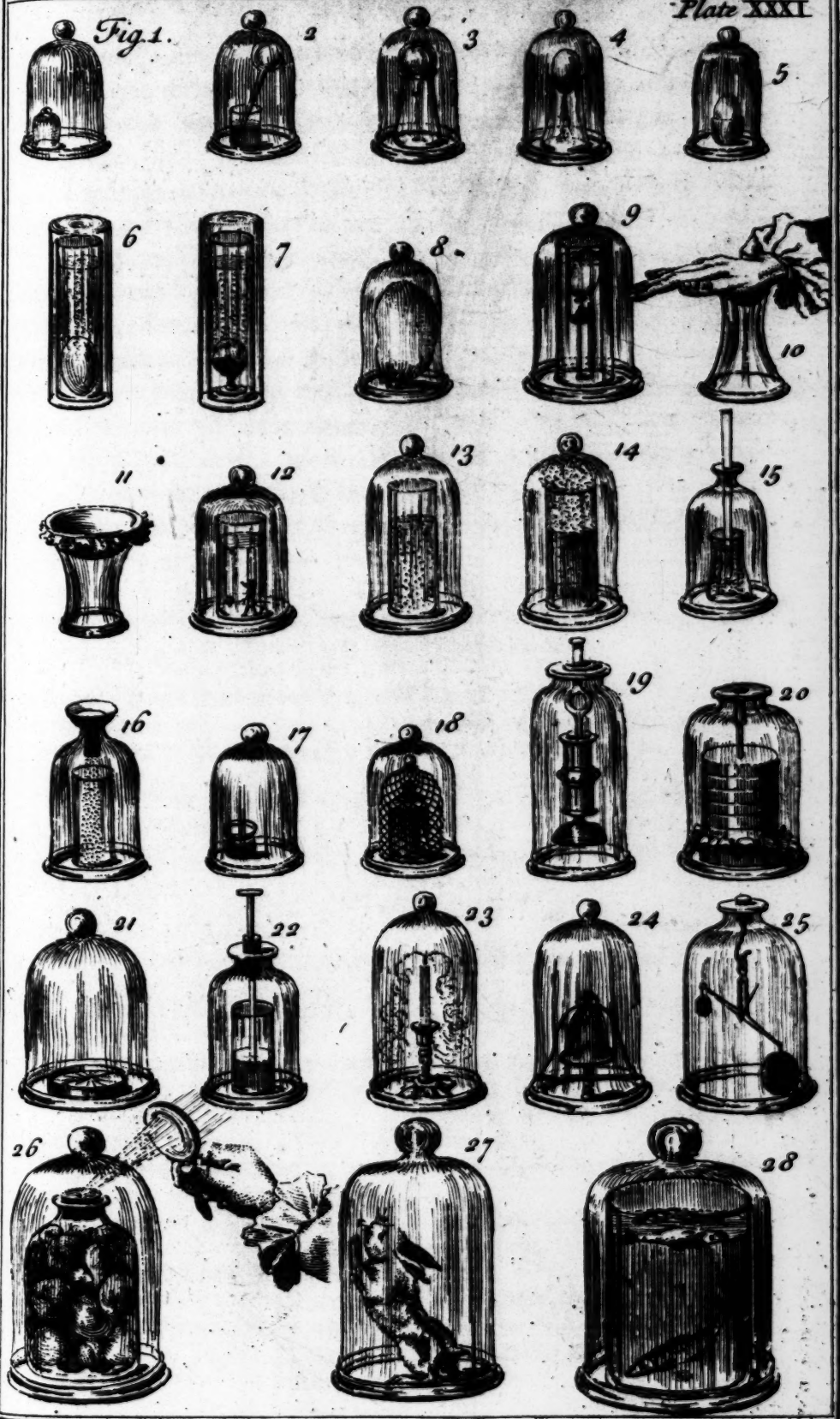
11. The Weight of the Air breaking a Bladder, (tied on a proper Glass) by its Pressure.

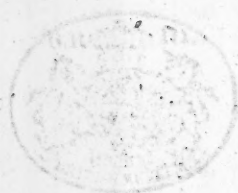
12. Small Glass-bubbles, and Images, raised from the Bottom of a Jar of Water, in *Vacuo*.

13. Shews

EXPERIMENTS on the AIR PUMP

Plate XXXI





Magnet, it attracts one End of the Needle; but, if I turn the other magnetic Pole, it repels this, and attracts the contrary End of the Needle, just in the same Manner in *Vacuo*, as in the Air.

Euphras. It certainly does: The Needle is put into Motion with the same Ease in one Case, as in the other; at least, I can see no Difference. — But what seems most wonderful, is, that the magnetic Virtue should not be interrupted by the Glass. I should have thought, it would have proved a very sensible Obstruction to the Influence of the Magnet.

Cleon. Not in the least, this Virtue is of such a surprising Nature, that it penetrates thro' any Sort of Substance, excepting Iron, with scarce any sensible Diminution of its Force, as I shall more particularly shew you hereafter, when we come to consider the Nature and Properties of this extraordinary Fossil.

E e e 2

— Then,

13. Shews the Air contained in Water.
14. The Air in Beer, rising into a frothy Head.
15. The Air, passing thro' a long Piece of Wood, render'd visible in Water.
16. Shews the Quick-silver, forced thro' the Pores of Wood, and descending, in the Form of a *Mercurial* Shower, into a Glass Jar below.
17. A Piece of Wood, immers'd in Quick-silver, to have its Pores injected therewith.
18. Shews a square Glass broke by the Spring, or Pressure of the Air.
19. Shews the Syringe descending by the Weight at Bottom, by the suspended Piston.
20. Several heavy Weights raised by the Expansion of Air in an empty Bladder under them.
21. Shews the Motion of a *magnetic* Needle in *Vacuo*, by a Loadstone externally applied.
22. A capillary Tube, immers'd in Water, to shew the Rising of that Fluid by Attraction, in *Vacuo*.
23. Shews the Candle going out, and the Smoak descending in the exhausted Receiver.
24. Shews the Air to be necessary for conveying Sound, by the ringing of a Bell, in *Vacuo*.
25. Shews the different Weights of Bodies in the Air, and in *Vacuo*.
26. Shews the Method of preserving Fruit, by exhausting the Air, and preventing its Return.
27. Shews the Air to be necessary for animal Life.
28. Shews Fishes are unable to abide at the Bottom of the Water, by reason of the Expansion of Air in their Bladders, and the Increase of their Bulk by that Means.

Then, as to the electrical Fluid, the Glass does no way obstruct its Action; for, if I take those small Pieces of Leaf-silver, downy Feather, &c. and place them under the Receiver, and draw out the Air;——then, you observe, by applying the excited Tube to the Side of the Recipient, the light Bodies will be attracted and repelled, in the same Manner as in the Air.

Euphros. It is certainly Fact. Neither the Glass, nor a *Vacuum* impedes the Action of this wonderful Power; which Thing I could not readily have imagined, if these Experiments had not verified it to my Sight.

Cleon. Then, as to the attracting Force of Bodies in general, it is the same in *Vacuo* as in the Air, which I thus demonstrate:——You see, this capillary Tube, being immersed with one End in Water, attracts that Fluid to the Height of one Inch within its narrow Bore above the Surface, and it will produce the same Effect, if it be immersed in the Water in *Vacuo*.——To this End, you see, a particular Apparatus is provided, in which the same capillary Tube is placed at a Distance, above the Water in the Receiver:——Then, having drawn out the Air, I thrust down the Wire, so that one End of the Tube descends into the Water, and you see, that the Water is instantly attracted, and rises to the same Height in the Tube as before.

Euphros. I plainly see it does; and from all these Experiments, I am thoroughly convinced, that the Powers of Nature are very wonderful. Bodies act upon Bodies with a penetrating Efficacy, in a Manner, too wonderful to be conceived or understood, without the Assistance of Philosophy.

Cleon. We shall now change the Scene for the following Act, and divert you a while with breaking of Bottles, by which the Weight and Spring of the Air will be farther demonstrated, and that their Effects are always equal to each other. For this Purpose, you see provided a Sort of Bottles, blown thin, and of a square Form, that the Air may have a greater Force on its flat Sides to break them.——On the Top of one is cemented a brass-Cap, perforated thro' and over the Hole is tied a small Piece of Bladder for a Valve, which admits a Passage out of the Bottle into the Receiver; but prevents

yents its Return. — Then, placing the said Glass on the Pump, under the Wire-cage, I place over all the Receiver. — And now observe, that having exhausted the Air from the Receiver, and consequently from the Bottle, as it cannot return into the said Bottle, when I turn the Stop-cock, it must fall round about it, and by its Weight and Pressure, it crushes the Bottle to Atoms, as you see.

Euphros. Yes truly, I saw, and heard it both; and the sudden Effect made me start. — I see from hence, how greatly the Form of a Glass prevents it from suffering by the destructive Pressure of the Atmosphere, and that a spherical and cylindric Form is necessary for the Receivers you use, to fortify them against so great an external Force.

Cleon. What you observe is very true; and I have heretofore mentioned to you the great Effects of confined Air, in bursting Bottles of Beer, Wine, &c. and shall now give you an Experiment of the same Kind upon the Air-pump. In this other square Bottle, the Air, which is confined by the Cork and Cement on the Top, so that, when it is placed under the Cage on the Receiver, and the Air begins to be exhausted, you will observe the Effect; — for, upon turning the Winch, I exhaust the Air gradually, and lessen its Pressure upon the Glass; but the Spring of the Air remaining, the same in the Bottle will at length prove superior to the Cohesion of the Glass, and Compress-force of the external Air, — which must necessarily burst it, as you see.

Euphros. I did not expect it quite so soon, but I consider the Bottles are very thin; and, if they were thicker, I suppose, the Effect would be too violent for an Experiment.

Cleon. That is the Case in all Experiments of a striking and surprising Nature. We take care to employ no more Force than what is necessary to answer the Purpose the Experiment is intended for. — As by many of these Experiments you have been taught, how great the Weight of the Air is, upon the Whole, I shall next shew you, that the Weight of this Fluid is very sensible in small Quantities, and that it may be weighed in a Balance, in the same Manner as any other Body is.

Euphros.

Euphras. This will be certainly a most agreeable Experiment! But I have not the least Notion how, or which Way that is to be done.

Cleon. You will find it is very easily performed, in the following Manner.——I have provided this *Florence* Flask, and cemented a Cap of thin Brass on the Top of it, with a small Hole in it, over which a Piece of Bladder is tied for a Valve; this will admit the Air to be drawn out of the Bottle; and prevent its re-entering, as you saw before.——This Flask I now place under the Receiver, and exhaust all the Air out of it.——Then, you observe, I let in the Air, and the Flask is not broke, by reason of the great Strength of this Kind of Glass, and its spherical Figure.——But the Air being exhausted, I hang it on the End of a Balance, and equipoise it with Weights in the opposite Scale:——Now listen attentively, and when I lift up the Bladder-valve with a Pin, you will hear the Air rush into the Flask:——And now, you see the Flask preponderates the Weight of the Scale, and goes down.——Then I put so many Grain-weights in the other Scale, as restore the Equilibrium, and consequently, shew the Weight of the Air contained in the Bottle.

Euphras. This Experiment is really very curious, and confirms the old Saying, “That every Thing is easy, when it is understood.” I should have thought it a more difficult and critical Matter to have weighed Air in a common Balance; but to my Surprise, I see you make no more of it, than a Grocer does to weigh a Pound of Sugar.——One Thing you must let me know, *viz.* how many Grains you put into the Scale to balance the Weight of the Air.

Cleon. Just *ten Grains*, and the Bottle, when nicely measured, will be found to hold one Pint and a Quarter; so that it follows from hence, that a Pint of Air weighs *eight Grains*, and consequently, a *Gallon of Air* weighs *64 Grains*, which is a little more than a *Dram*; therefore a *Bushel of Air* will weigh a small Matter more than eight Drams and a Half, or an *Ounce and Half a Dram*; by which you may easily understand what the Weight of the Air shall be in any other Bulk.

Euphras. Very easily, truly; you have, by this Experiment, given my Thoughts quite a new Turn, with respect to the
Weight

Weight of the Air, which I had no Notion of being so very sensible in small Quantities, as you have made it appear.—— But what is intended by this Syringe, with a Leaden Weight at the End of it ?

Cleon. I will tell you ; the Syringe has its Piston, different from that of a common Syringe, as it has no Valve, or Hole thro' it. This Piston, therefore, being placed at the Bottom of the Syringe, and the leaden Weight, screwed on the Outside with a Piece of Leather, to prevent any Air getting in ; then, when the Piston is raised, it must lift up the Column of Air above it, and consequently, make a *Vacuum*, in a great Measure, below. —— I let go the Piston, and it flies, with great Rapidity to the Bottom, by the Force of the Air's Pressure on it, by which you understand, that the Piston and the Syringe are firmly kept together by the Pressure of the external Air ; and consequently, if this Piston be suspended on the Hook of the Brass-plate, placed on the Top of an open Receiver ; then, upon exhausting the Air, and lessening its Force on the Syringe, the Weight of the Lead will cause the Syringe to descend from the Piston, and lower, in Proportion, as the Air is more exhausted.—— You see the Experiment.

Euphros. I do ; and it pleases me much, that I can, at the same Time, see the Reason of it ; and I further perceive, that, when you let the Air in again, it must force the Syringe up to the Piston again.

Cleon. That will be the Case. —— I turn the Vent-screw, and the Syringe returns, in a Moment, to the Piston.

Euphros. But these great Weights in a Box, which I see standing here ! What Kind of Experiment do you shew with them ?

Cleon. Still something of the same Purpose, *viz.* to shew the great Spring of the Air in any very small Quantity. —— For taking the Weights out of the Box, you there observe, at the Bottom, a Bladder, in Appearance, without any Air ; yet a small Quantity there is in it, which will be found sufficient to raise all those heavy Weights, by the Force of its Spring, when the Air is exhausted from the Receiver, placed over it. Observe the Experiment. —— I place the Weights on the Bladder in the Box, and with the first Turn of the Winch,
you

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you may just perceive them begin to rise. — The next Turn of the Winch makes the Air expand, and they rise more sensibly by the Side of the Vessel. — As I proceed in exhausting the Air, you see they continue to rise, till at length, they have risen more than an Inch higher above the Rim of the Box, than they were at first. — Hence you see how great a Force the Spring of that small Quantity of Air must be.

Euphros. One would hardly imagine, when one sees an empty Bladder, that there should be so great a Force concealed in it: Such Things would never gain Credit by bare Report, if they were not verified by Experiment. — One Thing has long taken my Eye in this miscellaneous Apparatus, and that is, the Guinea and large Piece of Cork, which I see appended to that fine Balance; but, I think, they seem not to be nicely equated in Weight, as the Gold appears to preponderate the Cork. — I suppose you have some interesting Point to establish by an Experiment thereby.

Cleon. A very material Circumstance of Statics depends upon this Experiment, which is intended to shew, that, when this Balance, with a Guinea and Cork, is suspended in the Receiver, that then the Cork, which now seems lightest, will then prove the heavier Body, and much preponderate the Guinea. I shall shew you the Experiment first. — To the Hook of the Brass-plate, I hang the Balance within the Receiver, and place it on the Pump. — Then, observe, that, by the first Turn of the Winch, there is a perfect Equilibrium between the Cork and the Guinea. — In two or three Turns more, you see the Cork manifest a greater Weight than the Gold, by its destroying the Equilibrium. — And when I have taken the Air quite away, you see the Cork preponderate the Gold, as far as the Beam will admit.

Euphros. This is certainly a very surprising Experiment, — I could not have imagined so great a Difference in the Weight of Bodies could have been occasioned by the Medium of Air; and tho' I know it is occasioned by the Air, I have not yet Philosophy enough to see thoroughly the Reason of it; in which Case, *Cleonicus*, I must beg your Assistance for a clear Apprehension of this Matter.

Cleon.



EXPERIMENTS on the AIR PUMP.

Plate XXXII.



Clean. You will hereafter see many Experiments to prove, that Bodies, moving in a Fluid, meet with Resistance from it, and that in Proportion more, as their Bulk are larger in equal Weight. — The Air is a Fluid, and the Cork of equal Weight with the Guinea, being many Times larger in Bulk, will meet in Proportion, with so much more Resistance from the Air; this Resistance will therefore oppose the Descent of the Cork, more than it does that of the Metal; and consequently, will diminish more of its Weight in a greater Degree. Therefore, when the Weights of those two Bodies are equal in the Air, it must follow, that, when the Air is taken away from the Recipient, the larger Bulk of Cork, which before was most resisted, will now prove the heavier Body; as you see in the Experiment; and hence it has happened, that a Hint from this Experiment, has put some of our saving Connoisseurs upon inspecting their Barometers, to learn from thence, the Density of the Air, when they propose to purchase precious Stones, or Things of great Value, sold by Weight, which are heaviest in the lightest Air. — Also, from this Experiment it appears, that a common Pound of Feathers is really heavier than a Pound of Lead; contrary to what is imply'd by the usual Catch.

E f f

Euphras.

An Explanation of the Figures, representing the Experiments in the Air-Pump, in Plate XXXII.

Fig. 29. A Fountain playing in an exhausted Receiver by the Pressure of Air.

30. Ditto by the Spring of the Air.

31. An Experiment, shewing the Rationale of Pump-work.

32. Shews the Manner how Halos are produced about a Candle.

33. Shews the Ascent of Quick-silver in a Tube, by the Spring of the Air.

34. Shews the same by the Pressure of the Air.

35. The Experiment of weighing Air in a Bottle.

36. — of burnt Air by a Charcoal Fire.

37. — of the exhausted Hemispheres applied to the Stiltyard.

38. — of a Gun-Lock in Vacuo.

39. — of Gun-powder not firing in Vacuo.

40. — of a Guinea and Feather falling together in Vacuo.

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Euphros. These Experiments shew the Use of Philosophy to Mankind, in rectifying our vulgar, and oftentimes, mistaken Notions of Things.

Cleon. The Truth, which you have now mentioned, will be farther confirmed by the next Experiment. — We hear the Sound of Bodies, but little think of the Means by which the Sense of Hearing is effected; nor do People in common appear concerned, to know the Reason of that wonderful Effect; though it be in a great Measure shewn very easily by the Air-pump. — For this Bell, which in the Air has so perfect, so loud, and so intense a Sound, will be found in the exhausted Receiver to have none at all. — For being suspended in this Piece of Brass, I screw it on to the Plate of the Pump. — Then, exhausting the Air, and shaking the Pump, you see the Clapper strike often the Side of the Bell, but hear no Sound in the least. — Hence you are immediately convinced, that the Air is the necessary Means of Sound, and how it is so, I must take an Opportunity hereafter more fully to explain, when we come to Experiments, which more particularly relate to the Organs of Sensation.

Euphros. I shall ever think myself happy, to find my Understanding enlarged by Degrees, and as I see by this Experiment, that Air is necessary for Sound; so I presume it is for Fire; since, by the Candle which I see here, I suppose, an Experiment of that Sort is intended.

Cleon. That is the Purport of the Candle: — For see; I light it, and place it under the Receiver, — and on the first Turn of the Winch, the Vigour of the Flame declines. — Upon the second or third Stroke, you observe, it declines by Degrees, and goes out. — I keep turning the Winch, and the Smoke, you observe, descends very copiously from the Wick, being much heavier than the rarified Air. — These are useful Documents, to acquaint us, how far the Air is necessary to support a Fire and Flame.

Euphros. Every Experiment I have found, by Experience, a Lesson of Instruction. I knew, that Fire much depended upon the Air being excited, and increased thereby at any Time; but was not before convinced, that it was so absolutely necessary to its Existence. — Pray, what means this Firelock,

Cleonicus?

Cleonicus ? I begin to have some Apprehensions at the Sight of it.

Cleon. You need not be under any Concern about that. — Your Maid every Day sets fire to her Tinder, and lights her Candle by that Instrument ; and you know, that the Means, by which she does this, are the Sparks of Fire, produced by the striking of the Flint against the Steel ; but, when I place it under the Receiver, no such Sparks appear. — This, you see, by the Experiment, several Times repeated. — You see no Sparks, and therefore no Tinder can be kindled in *Vacuo*. — By all which, you learn how necessary the Air is even to the very Appearance of Fire. — There is one Experiment more, which is usually shewn in Confirmation of this Doctrine, and that is, the letting fall some Gun-powder on a heated Iron in *Vacuo*, to shew there will be no Explosion.

Euphros. The very Mention of Gun-powder makes me shudder. I hope, there will be no Danger attending this Experiment ; if there be, I must prepare to get as far from the Pump, as the Limits of the Room will permit.

Cleon. I shall shew you no Experiment, where there is the least Possibility of your being hurt by it : The Apparatus is every Way secure. — You see a small Magazine of Powder, lodged in the upper Part of this large Receiver, through which there passes a small, hollow, Brass Tube, with Holes in its Sides ; as this is moved up and down in the Powder, a few Grains will get into the Tube, and fall from thence into the Bottom of the Receiver. — Then observe, this heated Iron is placed upon a small Iron Tripod, and in the Air, I drop a few Corns of Gun-powder on it. — They immediately take fire, flash, and explode ; but not so in *Vacuo*. — I take the ignited Iron, and place it on the Frame of the Pump, and cover it with a Recipient. — And now, observe, upon my pushing down the Wire, a little of the Powder falls from the Magazine upon the Iron, by the Heat of which they are melted, dissolved, and evaporated, without any Appearance of Flashing, or Explosion ; and all, you observe, proceeds from the Want of Air. — I turn the Vent-screw, and let in the Air, and then the falling Grains of Powder take fire from the Iron, and flash as before.

Euphros. Well, this Experiment has almost put me in a Tremor; and to tell you the Truth, I should be glad to take a little Turn in the Garden, to take the fresh Air; besides, I think it high Time, that you had a little Respite from the Fatigue of this Lecture; let us pursue the Remainder of these Experiments To-morrow, or the first Opportunity you have Leisure.

DIALOGUE XIX.

The Experiments on the AIR-PUMP continued.

Euphros. I Hope your explosive Experiments are now at an End; for though I take Pleasure in learning the Nature and Properties of the Air by them; yet they have so much of the Terrible in them, that I can scarcely conceit I am safe while you shew them.

Cleon. Our Passions are given us to a very good Purpose; they are a Kind of Armour to the Mind, and defend and fortify us against disastrous Events: Others operate upon us in a different Manner, moving Pity and Compassion towards every Object we see in distressful Circumstances; and this I am sure will be your Case in the next Experiment.

Euphros. I am jealous of some baneful Experiment to follow. It gives me Pain to hear you prelude to it thus. — I thought the Life of some Animal was in the Case. — See here comes *John*, with a lovely, young Rabbit. — I hope, that tender Creature is not to be sacrificed for my Sake. —

Cleon. You are like all the Rest of your Sex. — You think it Cruelty to attempt the Life of a large Animal, but are quite regardless of the Destruction of those which expire under your Feet in every Walk of Pleasure you take. — We know not but the Life of one Animal is equal to that of another: Little depends on the Bulk or Size of the Creature: If any Thing, it is an Argument against you, to say it is small; since all our Observations convince us, that whatever relates to animal Life, Sensation and Motion, is always more exquisite in

in those Creatures, in Proportion as they are smaller. — The Million of Mites in Cheese, of Eels in Vinegar, which are daily sacrificed for your Appetite's Sake, do not move your Commiseration so much, as this one single Rabbit, that can hardly be said to be more than half alive, and sensible, as being so young : — But to mitigate your Concern, I shall only shew, in this Experiment, that the poor Creature does really depend upon the Air for Life ; and after that, I shall put it into your Hands, as well as you see it now. — Here, *John*, put the Rabbit under the Glass. — And now, my *Euphrosyne*, have a good Heart, and look on ; for turning away your Face will boot the Animal nothing. — See, upon exhausting, how uneasy it appears. — As the Air is more rarified, the Animal is rendered more thoughtful of his unlucky Situation, and seeks in vain to extricate himself. — He leaps and jumps about. — A Vertigo seizes his Brain. — He falls, and is just upon expiring. — But I turn the Vent-piece, and let in the Air by Degrees. — You see him begin to heave, and pant. — At length, he rouses up, opens his Eyes, and wildly stares about him. — I take off the Receiver, and shall now deliver it as recovered from the Dead.

Euphros. Poor, innocent Creature ! I am grieved to think thou hast suffered so much on my Account ; but be assured, my Care shall be proportionably increased for thy future Safety and Welfare. Thou shalt always be my darling Rabbit ; as by thee, I have been obliged to learn how necessary the Air is for animal Life, and Respiration. — And, pray, *Cleonicus*, are these Fishes, which I see in this Jar of Water, destined to the same Fate ?

Cleon. Not intirely, but partly so. The Fishes which you now see frisking about at the Bottom of the Water, will, when they are placed under the Receiver, be obliged to ascend from the Bottom to the Surface ; and though, at the same Time, they will shew a constant Endeavour to regain their former inferior Situation, they will never be able to do it. — See the Experiment. As soon as I turn the Winch, they find the Difference of the Air. — You see the Bubble of Air ascend from their Mouths and Gills. — They appear uneasy, and their Bodies are expanded. — They continue to rise, at the same Time, they

they shew an Endeavour to descend.——You see two out of the three floating on the Top, and though not in the Agonies of Death, yet they seem greatly distressed, and lie with their Backs downward, as it were, in an expiring Posture, the Third is almost perpendicular, endeavouring to reach the Bottom, but cannot.——

Euphras. It is very disagreeable to see those poor Creatures in so miserable a Plight, when probably their Condition may be worse than that of Death. I have often observed the Air-bladder in Fishes; and I presume, it is owing to the Expansion of Air in those Bladders, that they are thus obliged to swim.——Pray, release them from their Misery, by letting in the Air.

Cleon. I will do as you require.——On turning the Vent-screw, you observe, their Bodies, as it were, contract, and by becoming less, they are rendered heavier, and by that Means able to sink, which they do with great Precipitation.——By this Experiment, you see how necessary the Air is, even for Animals that live in the Water, though they can shift with so small a Degree of finer Air, that it is not easy to kill them in the greatest *Vacuum* that can be made with the Pump; so far from it, that I remember Mr. *Hawksbee* tells us, he let two Fishes stand a whole Week in *Vacuo*, and they seemed to be brisker and better at last than at first, when the Air was drawn from them.

Euphras. The Usefulness of this Machine seems unlimited. What a prodigious Variety of Experiments are shewn thereby to explain the Nature of Things, and the important Properties of Air! What other Experiments remain, *Cleonicus*?

Cleon. Several, which it is proper you should be acquainted with.——You have seen the very great Weight of Air several Ways demonstrated, but one more remains, which will afford you some Pleasure.——These hollow, Brass Hemispheres are put together with a Leather between them, and by Means of the Stop-cock screwed into the Plate of the Pump, the Air is then drawn out of them, and by turning the Stop-cock, I prevent its returning again.——I hang them on to the Steelyard, and move the Weight upon the Beam, 'till such Time it is sufficient to separate them.——This, you see, happens

happens at the Number $127\frac{1}{2}$, which shews, that so many Pounds Weight are equal to the Pressure of the Air upon the Surface of the Hemispheres; and this agrees with what I have formerly shewn, viz. that the Pressure of Air upon every square Inch is equal to 15 Pounds, there being 8 square Inches and $\frac{1}{2}$ in the circular Area of one Hemisphere.

Euphras. This appears to be a very nice and certain Way of measuring, by Experiment, the Weight of the Air. — But besides the Experiment you formerly shewed me of the Quick-silver rising in the Barometer, by the Weight of the Air, I suppose you have other Methods of doing it by several Parts of the Apparatus I here see.

Cleon. You rightly judge of them, my *Euphrasine*. — I shall give you an ocular Demonstration, that the Quick-silver is supported in the Tube of the Barometer, entirely by the Pressure of the Air. Observe the following Process. — I take this small Basen of Quick-silver, and place it on the Plate of the Pump. — Then I invert this Tube, filled with Quick-silver, therein. — I place a Receiver over them, and — on the Top of that, a tall Tube close on the Top. — The Quick-silver is supported, you observe, to the Height of more than 29 Inches. — Then I turn the Winch, and by lessening the Pressure of the Air, on the Surface of the Quick-silver in the Basen, it descends in the Tube. — A second Stroke lessens the Pressure farther, and the Quick-silver descends still lower. — A third, fourth, &c. promotes the gradual Descent; — till at last, you see, the Tube almost evacuated, as the Quick-silver stands within but a little above the Surface of that in the Basen; all which plainly shew the Thing proposed. — But this is rather a negative Way of shewing the Thing. — You will see it positively and properly produced by the Pressure of the Air, when I let it again into the Receiver. — I turn the Vent-screw but a little Way, and the Air can get but very slowly in. — Then, you see, how naturally the Mercury rises in the Tube, 'till it has attained its former Height, and thereby measure the total Pressure of the Air.

Euphras. This is a very curious and full Proof of the Suspension of Mercury in the Barometer, by the Pressure of the Air.

Air. ——— But what means this other Apparatus of a long Tube, screwed into a Phial of Quick-silver?

Gleon. That is to shew how the same Effect is producible by the Spring of the Air. ——— For, you observe, the Air in the Bottle is confined, and cannot get out: ——— That the long Tube is open upon the Top, ——— and that therefore, when I cover the Hole with the Receiver, and tall Glass Tube as before, upon exhausting the Air, and taking its Pressure off the Surface of the Mercury in the small Tube, the Spring of the Air in the Phial will exert itself on the Mercury there, and force it up into the Tube, ——— 'till at length, having drawn away all the Air, the Mercury rises to the same Height, by the Spring of the Air in this Case, as it did by its Pressure in the other.

Euphros. A surprising Coincidence, and Equality of Effects, produced by the Spring and Pressure of the Air! ——— Here seems yet another Instrument, compounded of several Parts, to the same Purpose; pray, what is the Use of that?

Gleon. It is partly to shew the same Thing as before; but more directly exhibits the Rationale of Pump-work, as it demonstrates the Reason why, at every Stroke in the common Pump, the Water of the Well rises in the Pipe below, 'till it arrives in the Cistern, and there runs out; ——— for the Brass Syringe, or Barrel on the Top of the Receiver, represents the Barrel of the Water-pump. ——— The Mercury in the Bason, the Water in the Well, and the Glass Tube, immersed in it, shews the Pipe of the common Pump; ——— for now see the Experiment. ——— I raise the Piston of the Barrel, and thereby lifting the Weight of the Air off from that in the Glass Tube, the Mercury begins to ascend by the Pressure of the Air on that in the Receiver; which shews how the Water rises in the Pump by the same Means. ——— But now I place the Bason of Quick-silver under the Receiver, and the Brass Syringe on the Top, with the Tube immersed in the Mercury as before, ——— and draw out all the Air. ——— Then I raise the Piston, but no Mercury rises in the Tube, as there is now no Pressure of Air to produce that Effect. ——— From all which you are convinced, that the Medium of Air is the great Agent

Agent employed to actuate all Kind of Machinery concerned in the Pump-work of every Sort.

Euphros. I fear I shall tire you before you have done; as I see there are many other Parts of the Apparatus yet unused; but as I learn so much from every one, I shall, for my own Sake, bear with your Fatigue a little longer.

Cleon. Say nothing of that, Sister; for whatever improves your Mind gives me the greatest Pleasure. A few Experiments more will finish the usual Course, and the next shall be of Fountains, which play by the Weight and Spring of the Air;—for this Purpose, I take this Transferer, or Plate of Brass, with a tall Receiver on it, and by Means of a Stop-cock, screw it to the Plate of the Pump, and exhaust all the Air.—Then I take it off the Pump, having first turned the Stop-cock to prevent the Return of the Air to the lower Part, I screw on a Glass-tube, and then place it in a Bason of Water.—After this, I turn the Stop-cock, and the Pressure of the Air, on the Surface of the Water, forces it up, through a very small Adjutage in the Plate, in the Form of a curious Fountain, to the Top of the Glass, from whence it descends to the Bottom, and thus it will keep playing, till the Water rises to the Hole in the Top of the Adjutage.

Euphros. This is a very entertaining Experiment; but how do you apply the Apparatus to make the same Fountain by the Spring of the Air?

Cleon. Nothing more is necessary for this Purpose, than screwing the Stop-cock, with its Pipe, on a Bottle, partly filled with Water;—for this being done, when I turn the Stop-cock, the Spring of the included Air drives the Water thro' the Pipe into the exhausted Receiver, and plays the Fountain, as before.

Euphros. I think you call these artificial Fountains; and surely they deserve that Epithet.—I have heard much talk of the Experiment of the Guinea and Feather falling at the same Time to the Bottom of a Receiver in *Vacuo*. I suppose this tall Receiver is appropriated to that Use.

Cleon. It is so; and by this small Machinery of Brass, you see, it is very easy to let the Gold and Feather fall both at the same Instant from the Top.—I do this, while the Air is in the Receiver, and you see a manifest Difference in the Time

of the Fall; the Feather descending gently, and with an indirect Motion to the Bottom.——But now I will replace them on the Top, and exhaust the Air, and then,——look steadfastly at the Bottom of the Glass, and you see they both come there together.

Euphros. I observe they did; nor do I much wonder at it, when I consider the great Resistance that light Bodies meet with from the Air, but still I cannot say, that, supposing there were no Resistance at all, I clearly comprehend the Reason why a light Body should fall so soon as a heavy one; for Bodies fall by their Weight, and there is much more Weight in the Guinea, than in the Feather, and therefore, one would naturally think, it should fall sooner.

Cleon. Most People think as you do, that the Velocity of falling Bodies is proportioned to their comparative Weights; but this is entirely a Mistake; for the Velocity is proportioned to the Force of Gravity on a single Particle of Matter in any Body, and this Force, being equal upon all the Particles, produces an equal Velocity in Descent upon them all; and whether they are more or less in Number, and whether they are connected or disengaged from each other, does not affect the Case; for each Particle is still impelled with the same Force; and therefore, one single Particle, or any small Number, will descend, just as fast as any greater Number; which, in other Words, is only to say, that a light Body will fall just as fast as a heavy one, in an unresisting Medium.

Euphros. I make no Doubt but what you say is right, and that I shall one Day or other be more capable of conceiving the Nature of those physical Truths, better than I do at present; for now I chiefly attend to the Experiments, and shall, at my Leisure, reason upon them in the best Manner I can by your Assistance. But, pray, what means the Chafing-dish of flaming Charcoal just now brought into the Room.

Cleon. I ordered it not before, that it might not render the Air of the Room disagreeable; for it is designed to shew what pernicious, and deadly Qualities it imparts to the Air, that is affected by it, and impregnated with its Fumes. We have but too many melancholy Instances of People, who are suffocated, and killed by such a noxious and poisoned Air, owing
entirely

entirely to their Ignorance, how far the Air may be altered, with regard to its salubrious Property, by such Parts as it receives from subterraneous Fermentations, mineral Strata, and vitiated Air, passing through them. This we usually illustrate by the Air, passing through a Charcoal Fire, into the exhausted Receiver, in the following Manner.——I take a large, open Receiver, and place on the Pump, on which is placed a brass Plate, with a Stop-cock, and Crane-neck Tube of Copper.——Then, exhausting the Air from the Receiver, and holding the Chafing-dish of Coals, so that the End of the Tube may enter into a Part that is thoroughly kindled,——I turn the Vent-piece, and you hear the Air rush thro' the Fire into the Receiver.

Euphrosi. That I did, indeed.——But I see no Difference in that Air in the Receiver, and the common Air. I should not have suspected, that any Alteration had been made in the Air from what I see, in its passing through the Fire.

Cleon. But you will soon be convinced, there is a great Alteration made by that Means; for by putting a tender Bird, or other Animal, into the Receiver; filled by this Air, you would perceive it soon become stupified, afterwards convulsed, and at length expire; but such Sort of Experiments would give you more Pain than Pleasure: And therefore, I shall forbear them. It will be sufficient to shew you, that a Candle will immediately go out in this corrupted Air; for see the Experiment.——I place the Candle on the End of the Wire, and put it down thro' the Top of the Receiver, but you observe, as soon as the Flame descends, without leaving it floating on the Surface, it becomes extinct.——I try it a second Time, and it goes out as before; and this would be the Case, were I to attempt it an hundred Times.——I now let out a Part of the Air, by lifting the Receiver up, and let the Air from above force Part of it out from below.——Then I light up the Candle, and putting it down the Receiver, the Flame will soon appear to be affected,——is diminished by Degrees,——looks blue,——and at Length, is extinct.——I will now light it up again, and shew how this noxious Air may be purified by Fire;——for this Purpose, I gently carry the Flame of the Candle thro' all the upper Parts of it, which it heats by Degrees, renders it by

that Means lighter, and therefore, easily expelled by the Weight of the external Cold, and heavier Air; in this Manner it will soon be driven out of the Receiver, while you see the Flame of the Candle recover by Degrees; and burn at last with its usual Vigour.

Euphros. Such Experiments as these are calculated, I find, not only for Entertainment, but are of the last Importance and Necessity. Ignorance in natural Science is not only always shameful, but in many Cases extremely fatal. How many Lives might have been saved, and Families preserved from Misery and Ruin, had this one single Experiment of the Air-pump been known to the Populace of every Age and Nation.

Cleon. Your Reflections on this Head are very just and rational; but tho' Providence has reserved those very great Discoveries for this Age, we seem to be little regardful of them, or grateful for them; nor, as we receive the Benefits intended by them so generally, as might be expected. For Instances of Mortality of this Kind, by Damps in Mines, Effluvia, &c. are but too numerous and recent among us; when almost every Gentleman of Taste has an Air-pump in his Study. It would perhaps reflect too much on the Depravity of human Nature, to observe, with what Coldness, not to say Contempt, the most striking and entertaining Experiments of the Air-pump have been treated by some People.—I have only one Experiment more to detain you with at present. You have been, doubtless, amused, with observing the *Halo* about the Moon, in a hazy Atmosphere, in a Winter's Night.

Euphros. I have several Times observed that Phenomenon, not only about the Moon, but about the Sun. Pray, *Cleonicus*, can you explain the Nature of it, by any Experiment on the Air-pump?

Cleon. We can partly illustrate its Nature this Way; for it results from such a Refraction of the Rays of Light, as is made by their Passage thro' a Body of Vapours and Air, of a particular Density, as you will easily observe by the following Experiment.—I take a Candle, and place it on that Side of the Receiver opposite to you, so that the Flame may be seen thro' the upper and larger Part: I then turn the Winch, and exhausting Part of the Air, make it of a proper Density, and, at the same

same Time, filling it with Vapour, or aqueous Particles, from the moistened Leather below; the Effect will be, that the Rays of Light, passing from the Candle thro' this Medium-Air in the Receiver, will cause the Appearance of *Halos* round the Candle to your Eye, of different Colours and Extent—variable, as I make the *Vacuum* greater or less.—If I take the Air quite away, they disappear, as they do also, by letting the Air in again.

Euphros. They make a beautiful Appearance indeed!—I observe them vary in their Colour and Magnitude, according to the different Density of Air, and Quantity of Vapour it contains.—From thence I am convinced of the general Nature of such Appearances.—Upon the Whole, *Cleonicus*, however lightly others may pass by these great Topics of natural Knowledge, I shall, for my own Part, ever reflect on them with the greatest Pleasure, and think myself indebted to you for the Pains you have taken to lay them before me in so instructive a Manner; and nothing will appear so astonishing to me, as to hear any Gentleman of Fortune, Spirit, or Genius, should be without an Air-pump in his Possession.

DIALOGUE XIV.

The Nature, Structure and Use of the CONDENSER, MERCURIAL GAGE, AIR-GUN, and VENTILATOR.

Cleon. THIS Morning, my *Euphrosyne*, finishes our Conversation on Pneumatics; for tho' you have seen a Variety of different Kinds of Machines for explaining the Nature and Qualities of the Air, there still remain some, whose Uses are too considerable not to deserve your Notice. Those you have already contemplated, chiefly regard the Weight and Spring of the Air in its natural State. But it will be worth your While to consider how far the Spring of the Air may be increased by artificial Compression, and the great Effects that are thereby produced.

Euphros.

408 *The young GENTLEMAN*

Euphros. This is a Subject that will prove very grateful to me, provided you have nothing dangerous in these Sort of Experiments; for I have learned to know, by what has already passed, how very great Effects may be produced by the Spring of the Air, and I see some Parts of your Machinery here are particularly calculated against so great a Force: Pray, what do you call this Machine which stands here? *

Cleon. It is commonly called the CONDENSER, because by Means thereof, the Air may be compressed almost to any Degree we please; for the two brass Cylinders, being placed together with a Leather between them, and screwed fast upon each other in the Frame, as you see, the Air thrown in by the Piston on the Top, till it is rendered so dense, and its Spring of Course so great, as we judge the Strength of the Brass will admit. This is done, by placing the Valves in the Barrel and Piston the contrary Way, to what you observed in those of the Air-pump; for as they opened upwards, these open downwards, by which Means the Air that is crowded into the Condenser cannot possibly return, and thus Experiments may be shewn on Animals, Vegetables, Fire, and any Sort of Subject included in this condensed Air. Mr. Boyle has left us a great Number of Experiments on this Subject, by which he has shewn, that Animals may be killed by a too great Condensation of Air;—that when condensed to a moderate Degree, he has found them to live longer than in common Air.—That compressed Air affected Flies, Frogs, and such like Animals but very little.—That Mouldiness is promoted nearly in Proportion, as the Air is condensed.—That Vegetation is not prejudiced by condensed Air;—and many other Things of Consequence you will find in his Treatise on this Subject, to which I refer you.

Euphros. I see but one Objection to this Machine, and that is, one loses the Pleasure of seeing the Experiment in a great Measure, by the Subject's being included in a Vessel of Brass.

Cleon. The brass Condenser is used only in such Cases where great Degrees of Compression are required, in all other Cases a strong Glass,—such as you see here. †—In this you place the Animal, Plant, &c. and then condensing the Air upon it with the Syringe, as before, you will have the Satisfaction of observing the Process, and plainly see the Effects which condensed Air has upon different Subjects placed therein.—In this glass Condenser you may venture to force the Air in so far, as to render it three or four Times more dense than the common Air, which will be sufficient to answer most Purposes.—Moreover, you may at any Time know how dense the Air is, by a small mercurial Gage, placed in the Condenser, and which

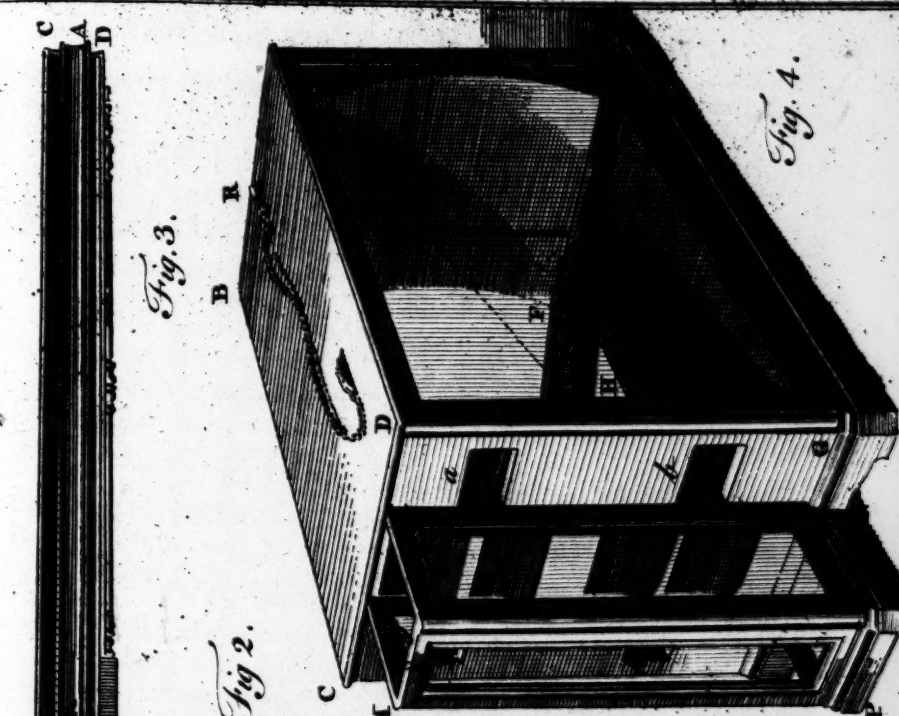
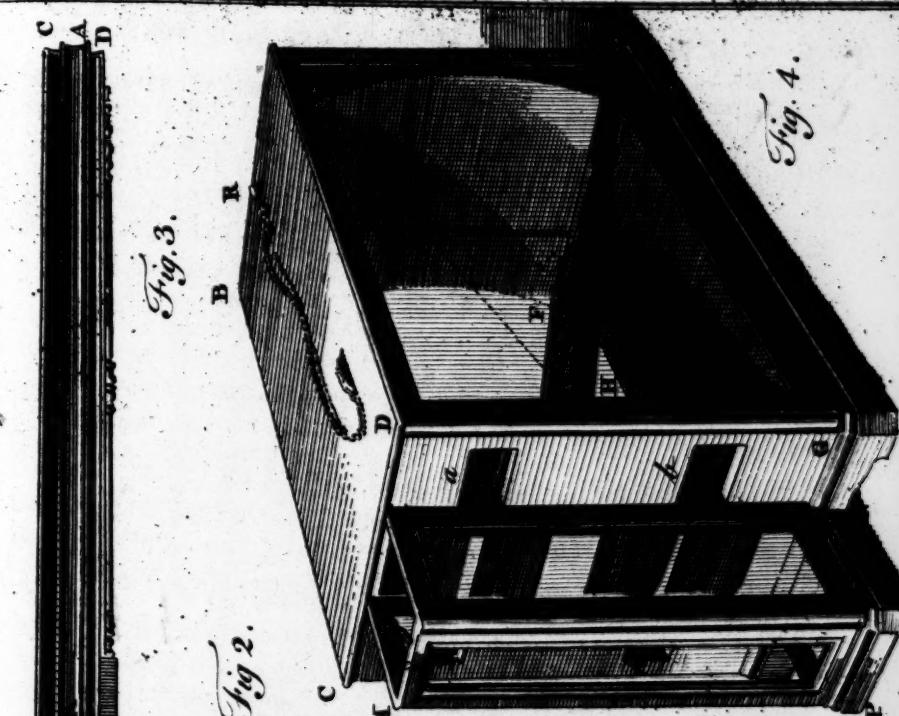
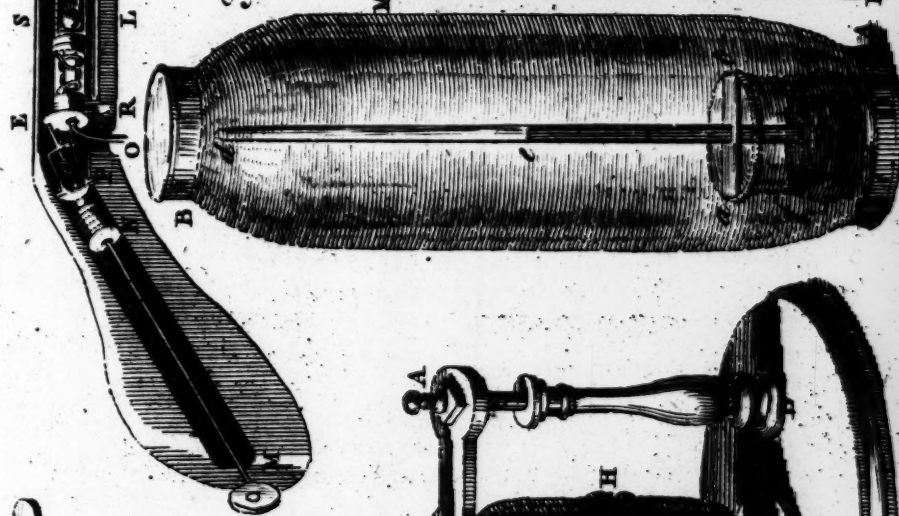
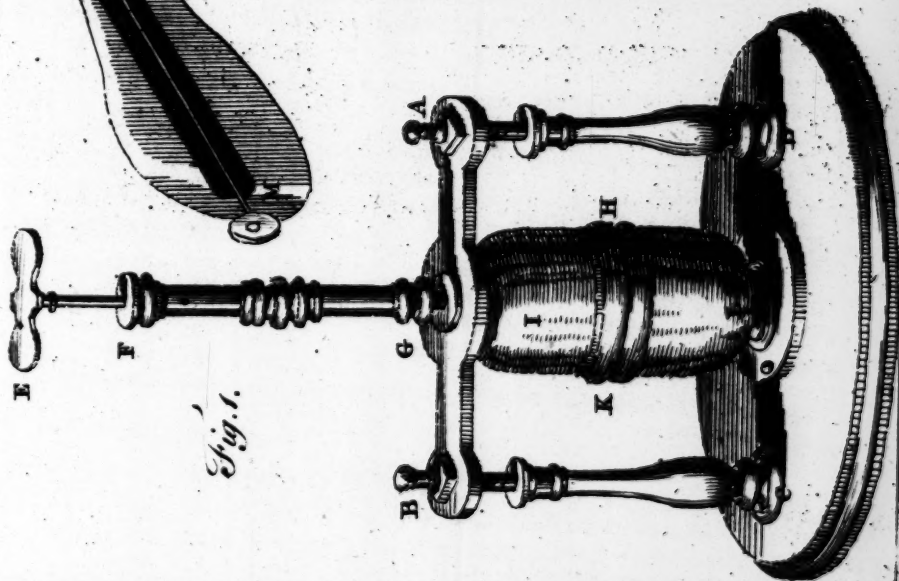
* Figures of Plate XXXIII. described.

A B C D, The Frame of the Condenser.—H I K H L K, The two Brass Cylinders, or Parts set together at H K.—F G, The Brass Barrel, or Syringe.—E, The Handle of the Piston, by which the Air is injected.

† Figure II.

A B, The Glass Condenser.—a b c d, The Mercurial Gage.—a b c, The Basin.—f g, The Surface of the Quick silver in the Basin.—c d, The inverted Glass-tube.—, The Surface of the Mercury in the Tube.

PLATE XXXIII.



A. Walker Sc.



which I have provided on purpose to shew you the Experiment; for the small Tube being inverted in a Bason of Quick-silver, you will observe,—that as I force the Air into the Glass, it condenses the included Air, and pressing with a greater Force, drives it by Degrees up into the Tube,—and higher than before at every Stroke of the Piston.—When the Quick-silver fills half the Tube, the Air is of a double Density,—when it fills $\frac{2}{3}$ of the Tube, the Air is three Times denser, and so on; for the Density of the Air is always inversely, as the Space it takes up, as you will easily understand.

Euphros. This will be the natural Result of Compression in any Body.—But, pray, *Cleonicus*, what is the Design of this Gun?—I remember you told me, our explosive Experiments were at an End, if so, why then this Fire-lock?

Cleon. It is a Gun, in Form like others, and has a Lock, but neither Fire nor Powder is here necessary.—The Method of discharging this Gun, is by Means of condensed Air let in behind the Ball in the Barrel, and therefore it is called the *Air-gun*.—This Gun consists of two Barrels, and the Air is strongly condensed between them, by Means of a Syringe placed in the Butt-end.—But that you may have a more perfect Idea, I shall take the Gun to Pieces, and shew you the several Parts. †

Euphros. You are very obliging, *Cleonicus*, the View of such a Piece of Mechanism gives me the greatest Pleasure.—But when you discharge it, let me get at a Distance from you.—

Cleon. You have nothing to fear.—Observe the Board at the Distance of 30 Yards.—I draw the Trigger;—The Bullet you see has passed thro' the Board,—and beat a Hole in the Brick of the Wall, several Yards behind it;—another Discharge, with the same Air, has the same Effect;—a Third carries the Bullet thro' the Board, as at first.—

Euphros. Well, this is a philosophical Method of shooting, truly!—I could not have thought the Strength of Air had been so near to that of Gun-powder.—But see, what is this other curious Machine in Glass?

Cleon. You have often heard talk of Ventilators, for discharging the noxious Air from close Rooms, in Prisons, on board a Ship, &c. and I have here a Model of one in Glass ‖, that you may plainly

† Figure III: explained.

C E M D, The Air-gun. — A K, The Barrel for the Bullet. — E C D R, The larger Barrel containing the Air. — M N P, The Syringe in the Stock of the Gun. — E P, The Valve thro' which the Air is driven from the Syringe into the Space between the Barrels. — K, The Bullet lodged in its proper Place. — S L, Another Valve, which being pushed open by O, the Trigger, lets the condensed Air in upon the Bullet, which drives it out with very great Force.

‖ Figure IV.

A B C D E F G, The Body of the Glass-ventilator. — I K L M N O P, The Glass-case in Front. — F H, A Board that moves up and down. — Q R, The String by which it is moved. — a g, The two Valves in Front at Top, by which the Air enters into the Ventilator. — c d, Two Valves, by which the Air goes out of the upper Part into the Glass-case. — b b, Two Valves in the lower Part of the Ventilator, by which the Air of the Room enters into it. — e f, Two Valves, by which the Air is forced out of the lower Part into the Glass-case.

ly see its Nature, and Manner of Operation.—You observe the Body of the Machine is a Box, within which a Board is hung to the Middle of the Fore-part, and is moveable backward and forward, from the Bottom to the Top, as the Hinder-part, and by Means of Leathers on its Sides and End, is so exactly adapted to the internal Cavity, as to suffer little or no Air to pass by it, as it moves up and down, —You move it upward by the String, and a Plate of Lead carries it down again to the Bottom.

Euphros. Pray, let me work this Machine. — It moves up and down very easy. — But what are those Leathers in the Fore-part, which move so quick one Way and the other, while the Machine is in Motion.

Cleon. They are the Valves, which perform the Office of those in a Pair of Bellows ; for when the Board is lifted up, the Air rushes into the lower Part, thro' two Valves placed in Front, — and at the same Time it is driven out of the upper Part, thro' two Valves into a Glass-case, fixed in the Front of the Machine. — Again, when the Board descends, the Air rushes in thro' two Valves in the upper Part, which open inward, while that below is driven out of the Box into the Glass-case, by two other Valves below : — Wherefore you will easily understand, that by making an Aperture in the Window, or Side of the Room, to fit the said Case, or a close Tube coming from any Part of it, that then every Time the Board moves up and down, so much Air of the Room will enter the Ventilator, and be thrown abroad, as is just equal to Half its Capacity, or Bulk, and therefore, one may pretty easily know, at how many Strokes, and in what Time, the vitiated Air of any Room may be exhausted, and the Room filled with that which is fresh and healthy ; — and these are now so adapted for Use, that they may be applied to any Room in a House, even in Gentlemens Studies and Bed-chambers, to a very good Purpose.

Euphros. I understand all you have said very well, and do assure you, I like the Contrivance so well, that I design to get one for my own Use. — But my Time is expired, at present, having an Engagement the Remainder of the Forenoon ; but shall be glad to know what Subject we are to enter upon at our next Interview.

Cleon. We have taken a Survey of the Heavens, and the Atmosphere that surrounds the Earth, which naturally conducts us to contemplate the Figure of the Earth, and its various Phenomena, together with those of the Heavens, which will bring us to the Use of the ARTIFICIAL GLOBES, which will be the Subject of our future Hours of Leisure.



The End of the First VOLUME.

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